POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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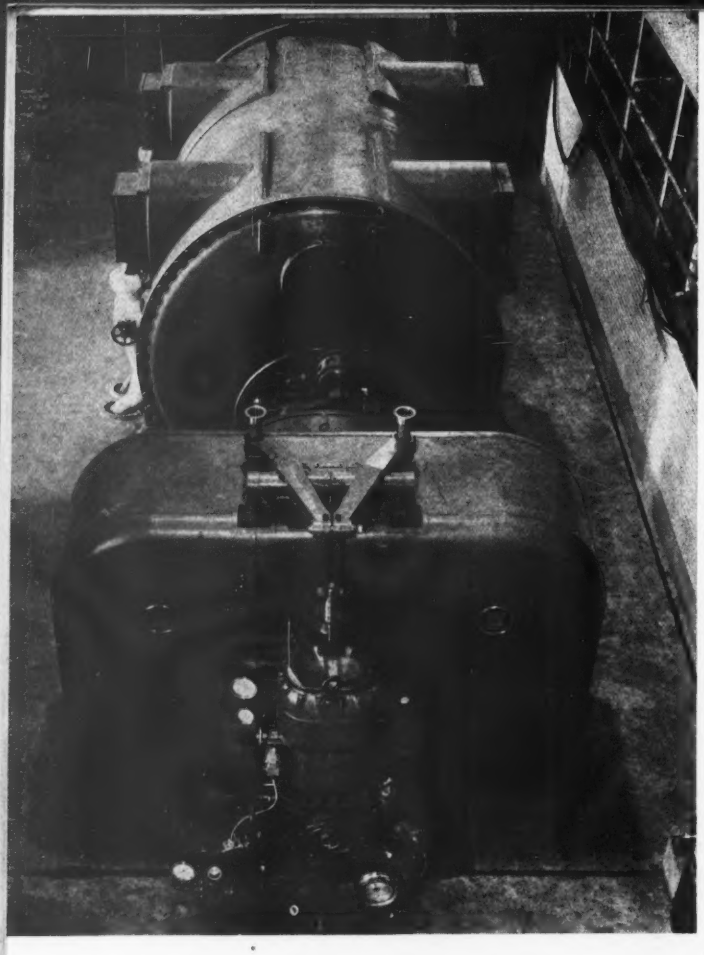

THE COMMONW'TH & SOUTHERN SYSTEM
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THE STANDARD GAS & ELECTRIC SYSTEM
Public Utility E. & S. Corp.

Tomorrow's Plants Today

ANNOUNCEMENT is made on the second page following of a series of articles painting a comprehensive and vivid picture of American power plant practice as it exists today and as it will exist during the next few years. This is the first time an attempt has been made to give a complete, nation-wide outline of an unprecedented construction program ushering in a new period of high-pressure, high-temperature power plant design which is destined to dominate the power industry for the next three or four years.

It is POWER PLANT ENGINEERING'S contribution to the industry, a contribution intended to acquaint engineers with what is going on behind the scenes today, what will be an accomplished fact tomorrow and what may be expected in years to come—a graphic picture of the industry as a whole in sufficient detail to show the practice of specific companies.

Whether the series is extended beyond the articles outlined above, each article by an author well known in the field and playing an important part in the construction program about which he writes, depends upon how well the editors have interpreted the needs of the industry, how well the first authors answer the unspoken questions in your mind and, most important, how freely you cooperate with us by means of suggestions, comments or criticisms of individual articles or the series as a whole. We cannot interview each reader personally, but we depend upon your cooperation through the mail to guide our future action.

WITH THE EDITORS

Utility Millennium?

PEACE ON EARTH and Good Will to Man may be just an idealistic dream to the world in general but, like the European Nations, the gas and electric utilities apparently have advanced to the point where they believe in the Golden Rule. At least a form of the Golden Rule modified to "Do unto others what you think they will do unto you."

The feud which has been becoming more acute with the spread of natural gas lines and recent small engine developments has been going on for some time and was brought out into the open recently at an Industrial Gas Sales conference. In discussing a new plan for promoting the sale of gas for power production, it was said:

"No sizable promotional program was ever embarked upon that did not present some obstacles as a challenge. We need not expect immunity here. . . . We must meet the problem of electrical competition with alertness, resourcefulness, and determination. Whatever gains we may make will be at the expense of the power companies. If this plan offers a hope to the gas industry then, conversely, it constitutes a threat to the electrical industry. We may depend upon it that they will fight to the last ditch and with every means at their command. They will revise rate structures, if possible, to make our application less profitable. They may attempt increases in the demand charge. They may attempt to levy excessive fixed charges on the argument that they are rendering stand-by service. They may attempt to trump up fictitious values for their excitation service. For a period of time, the battle lines will be shifting and it will require vigilance and intelligence on our part to parry these counter attacks."

Being in the Administration doghouse, it is not likely that the electric utilities will be quite as outspoken in accepting the challenge but this does not mean that the old squirrel guns will not be in condition for a bit of systematic sharpshooting as occasion demands.

Regulation Seems Necessary

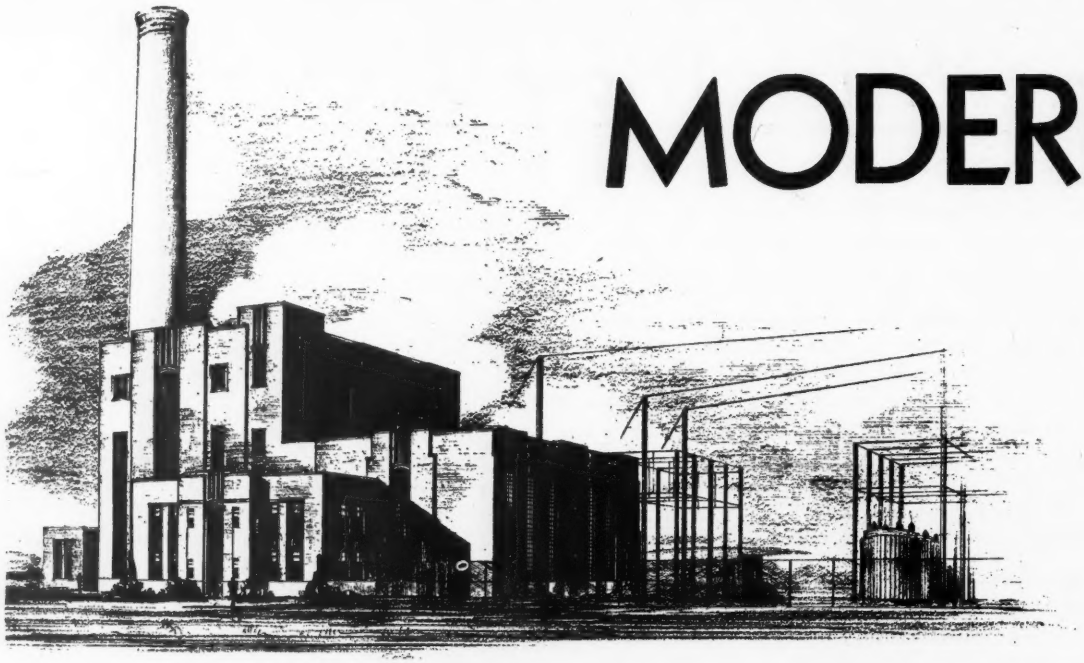
THAT SOME SORT of supervision and regulation of promoters of power developments is desirable is made evident in a recent ruling of the Federal Power Commission on an application for license for building plants on the Gasconade River in Missouri. Application for a permit was filed in 1928, permit granted in 1929 and application for license filed in 1932, thus gaining priority rights over other applicants. Request was made in 1937 that action on the license be delayed a year and 2 yr. additional be allowed before beginning of actual construction, which, if granted, would have given 11 yr. from issue of preliminary permit to starting construction, whereas 7 yr. is the time provided by statute. So long an option on a possible power development is hardly reasonable or in public interest.

Reasons given for asking so extended a delay were to give opportunity for marketing power and for financing the construction. If there were need for the development, it would hardly seem likely that 11 yr. would be required to market the power. When the proposed financing is examined, the reason for failure to secure financial support appears. Estimated cost of construction and financing was $10,000,000, to be raised by marketing $7,500,000 first mortgage bonds and $2,500,000 income bonds, leaving no capital to be furnished by the promoters, except possibly cost of the site for the project. Soundness of such financing is questionable. As to income, the promoters proposed sale of 72,000,000 kw-hr. of primary power and 77,500,000 kw-hr. of secondary power annually, while the Commission's engineers estimated 73,000,000 kw-hr. of primary power and 28,300,000 kw-hr. of secondary power as available annually, at 50 per cent load factor. On this basis, total revenue would be less than the operating expense, taxes, depreciation and interest estimated by the promoters, and $200,000 less than the total expense estimate of the Commission's engineers. Obviously, marketing of bonds under such conditions should be difficult, and they would be an investment of at least doubtful value.

So long as such projects are promoted, supervision and regulation are obviously needed, and action of the Commission in denying the application is to be commended. It is to be regretted, however, that government developments of power sites are not subjected to the same careful analysis by the Commission as to probable cost and returns before the taxpayer's money is spent to finance the developments. Safeguards against involuntary unprofitable investments is as important to the public as safeguards against exploitation by private promoters.

Ash in Fuel Oil

DISCUSSION at a recent A. S. M. E. meeting brought out the important part ash in fuel played in the life of a Diesel engine or rather on certain parts of the engine, namely liners. Under certain conditions of continuous operation using a fuel of 0.03 per cent ash, liner life ranged up to from 6 to 8 yr., wear in 16,000 hr., or about two years operation, being approximately 0.032 in. With a fuel containing 0.08 per cent ash the life period was reduced to 2 yr. as a maximum. Comparative data on other stations for low ash fuel shows a wear of 0.0355 in. after 16,428 hr. of operation and for still another 0.0455 in. after 26,239 hr. of operation. These were all for large or fairly large slow and medium speed engines, the performance of which is now reasonably well established. What we need now is similar data on the newer light weight high speed units. There is still considerable skepticism as to whether these units can stand continuous hard service without excess maintenance charges.



MODERN

I—Commonwealth & Southern System

By Geo. C. Daniels
Chief Mechanical Engineer
The Commonwealth & Southern Corp.
Jackson, Mich.

PROPERTIES comprising the northern group of the Commonwealth & Southern Corp. are owned by the following companies: Consumers Power Co.; Ohio Edison Co.; Central Illinois Light Co.; Southern Indiana Gas & Electric Co.; Pennsylvania Power Co. The territory served and the location of the generating stations of these companies are shown on the accompanying map. The installed capacity of the various steam generating stations is given in Table I.

From 1929 through 1936 no new generating units were installed on the Commonwealth & Southern Corp. system with the exception of a 12,500-kw., 400 lb. pressure turbine put into service in the spring of 1936 for the Southern Indiana Gas and Electric Company in their Ohio River Plant at Evansville, Ind. During the close of this period the electric load had again reached the 1929 level and plans for increasing the generating capacity to meet the expected load increases for the various territories served were made.

Elm Street

Superposition of high pressure units on existing plants was carefully considered but found to be economical in only one case, namely, the Elm Street Station at Battle Creek, Mich., of the Consumers Power Co. At this plant there was a deficiency of circulating water and insufficient steam from the 200 lb. pressure boilers to supply more than 30,000 kw. of the 40,000 kw. of installed turbine capacity. By installing a 10,000 kw. topping turbine, operating at 800 lb. pressure and 850 deg. F. steam temperature, and a boiler with a capacity of 360,000 lb. of steam per hr., the available station capacity was increased by more than 20,000 kw. and the efficiency of the plant, up to the steam capacity of the high pressure unit or 30,000 kw., was increased by approximately 30 per cent. This unit was placed in operation in September, 1937.

New Stations

Late in 1936 it was decided to build three new steam generating stations and add capacity to three existing stations which were operating at 400 lb. pressure and 700 deg. F. steam temperature. These plants and additions are now in the process of construction. The new plants and additions to existing plants now being built or designed are shown on Table II.

The policy of the company in the design of its generating stations or plants has been conservative. Lowest overall cost of producing current has been its aim and not to establish a record for high plant efficiency. Simplicity of design and operation has been

UTILITY STATIONS

This is the first of a series of articles dealing with the current building program of the American public utility industry, an unprecedented, nation wide expansion involving well over 100 plants and made necessary by the cessation of building during the depression and the rapid growth of electric load during the recovery years. Some of these plants are additions to old stations, some are completely new; some are "tops", others are condensing; a few are already in service, many more are under construction, some are still in the design stage. The large number of plants involved precludes individual detailed descriptions but fortunately the majority have been designed by a relatively few engineering organizations and have much in common so that they lend themselves well to group treatment. This makes it possible to give a comprehensive picture of present practice and trends, a picture more significant than that formed by a series of disconnected detailed power plant studies

deemed essential to low operating cost. A simple regenerative heat cycle, without reheat, which has been employed in previous designs of the company's 400-lb. plants has been used in the design of the new higher pressure plants.

In the choice of operating pressures 1200 lb. per sq. in. was considered but 800 lb. per sq. in. throttle pressure was decided upon since the station economy obtainable with a straight condensing, single shaft turbine of 3600 r.p.m. operating with a steam pressure of 800 lb., and a temperature of 900 deg. F. was within 2 per cent of that obtainable with a similar turbine operating at 1200 lb. per sq. in. and 900 deg. F., and the extra cost for the 1200 lb. pressure could not be justified. Somewhat larger single shaft 3600 r.p.m. turbines could be built for 1200 lb. than for 800 lb. pressure but sufficiently large 800 lb. pressure turbines could be obtained for any of the company's present system requirements, namely, 35,000 kw.

One Boiler per Turbine

Steam temperature was established at 900 deg. F. since this could be obtained in the turbine without additional cost above 826 deg. F. The superheat from the boilers can be regulated to a maximum of from 850 to 900 deg. F. Since the overall plant efficiency under the above steam conditions would be approximately 20 per cent higher than the 400 lb. per 700 deg. F. temperature units in the present plants, the additions to these plants will be built for the same steam conditions as the new plants, namely, 800 lb. and a maximum temperature of 900 deg. F.

A single boiler per turbine has been decided upon since past experience has indicated that the availability of the modern boilers is as high as the turbines and the boiler outage can generally be scheduled. A single

THE COMMONWEALTH & SOUTHERN CORP. is one of the larger holding companies and has been much in the public eye of recent years through the activities of its dominant and militant president, Wendell L. Wilkie, in defending the rights and privileges of the industry against Government competition. The operating companies which comprise the system are located east of the Mississippi River and are grouped in two general divisions, the Northern and Southern, separated by the Mason and Dixon line.

The territory of the T. V. A. cuts diagonally across the northwest corner of the Southern Division and capacity additions are naturally closely tied in court decisions now pending and which are expected to define and perhaps limit the scope and activities of the T. V. A. At present two steam plants are under consideration by the Southern Division, a new 800 lb. 850 deg. F. condensing plant with one 20,000 kw. unit for the Tennessee Electric Power Co. at Nashville, Tenn., and a 800 lb., 850 deg. F. addition with two 35,000-kw. units for the Atkinson plant of the Georgia Power Co.

Only the building program of the Northern Division, involving additional generating capacity, is covered by this article. Probably the most remarkable feature of this program is the unusual degree of standardization achieved in eight plants built to serve widely separated areas. Extensions, tops and new plants are all based on a throttle pressure of 800 lb. 850 deg. F.; one boiler per turbine; all electric auxiliaries supplied from auxiliary windings of the main transformer; single shaft turbines driving generators connected direct to the low side of the main transformers; a simple but efficient heat cycle with three closed extraction heaters and condenser deaeration.

Recent developments in high temperature and hydrogen cooling were taken advantage of but the temperature was held to 900 deg. F. max. to avoid the added cost of special alloys for the higher temperature range and the possibility of outages arising from extremely high temperatures and which, as yet, lack a full background of operating experience.

Many of these are isolated stations carrying all or the major portion of the load so continuous service is a major prerequisite. This was one of the factors involved in the selection of 800 rather than 1200-1400 lb. With the temperature limits set, the higher pressure would have meant higher moisture contents in the turbine exhaust, with a greater danger of blade erosion with attendant maintenance charges and interrupted service.

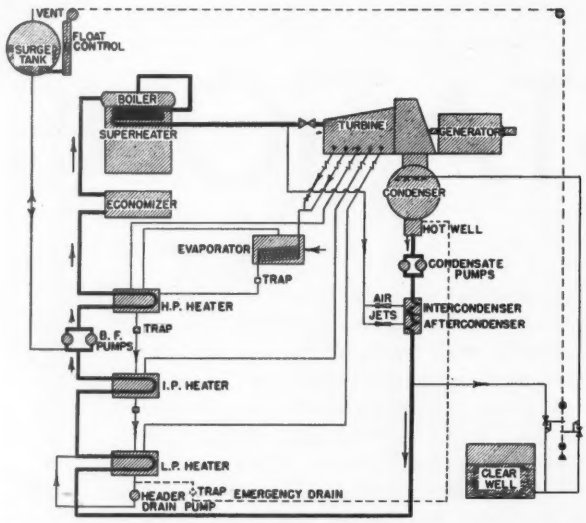


Fig. 1. The flow diagram which is identical in all stations. The turbines are bled at five points, the lower three for supplying the extraction heaters, the two higher for operating and cracking the evaporator. All closed heaters are used, with a thermostatically controlled bypass on the intermediate heater to maintain a constant temperature to the feed pump at all loads in order to prevent flashing in the surge tank. The clear well and storage tank arrangement with a single float control and condenser deaeration has been a characteristic feature of the company's plants for many years

boiler per turbine results in a substantial reduction in capital expenditures, and, with turbine units of 35,000 kw. and smaller, the boiler reaches only a moderate size, namely, 400,000 lb. of steam per hr. for the 35,000 kw. units.

Special attention has been given to the selection and the design of the boiler auxillaries and boiler appurtenances since much of the boiler outage is usually chargeable to trouble outside of the boiler itself. The boilers will be cross connected and the feedwater system will be common to all boilers. Pulverized fuel firing with dry bottom furnaces is used throughout.

A typical heat balance diagram used in all of the plants is shown in simplified form in Fig. 1. An essential feature of the system is the elevated surge tank of relatively small capacity, which is connected to the common suction of all of the boiler feed pumps. A substantial float in this surge tank maintains a practically constant water level by operating the control valves, either discharging cold water from the discharge of any of the condensate pumps to the condensate storage tank, or supplying make-up water from the condensate storage into any of the condensers in operation. This water is sprayed into the condenser and deaerated.

Surge Tank

In actual operation there is little water going into or out of the surge tank and consequently there is no danger of absorption of oxygen from this source. During the time that the evaporators are in operation the surge tank water level raises sufficiently to cause a constant flow of cold condensate to the condensate storage and when the evaporators are down there is a small, practically constant, amount of water supplied to the condensers from the condensate storage.

Turbines are supplied with five bleed connections, the lower three supplying the extraction heaters and the upper two supplying the operating and cracking lines to the evaporators. Two closed feedwater heaters are installed ahead of the boiler feed pumps and raise the temperature of the condensate, after passing through the inter and after condenser of the air ejector, to 215—220 deg. F. The temperature in the intermediate pressure heater is controlled by a thermostatic valve by-passing a portion of the water around the heater.

After the boiler feed pumps the feedwater passes through the high pressure heaters, arranged for parallel operation with one high pressure heater per turbine. Thus, while each turbine heats its own feedwater up to the temperature of the intermediate heater, the bleed from the turbines to their high pressure heaters depends upon their respective loads and the pressure drops.

Heater Drains

Objections to this method of operating the high pressure heaters is not as great as the advantages gained by the simplicity and the ability to operate the plant with a common feedwater system and the boilers interconnected. The evaporator is supplied with steam from the second bleed point and discharges into the high pressure heater. This assures less carry-over of solids from the evaporator. Each heater cascades its drips into the next lower pressure heater, and, from the low pressure heater, the drips are pumped into the feed line past the low pressure heater. Air vents go directly from each heater into the condenser and the air removal capacity is controlled by means of a plug valve.

Contrary to usual practice, no deaerating heaters are used but the condenser is relied upon to give oxygen free condensate. Specially constructed condensate pumps and heater drain pumps are used that assure

Table I. Installed capacity of steam generating stations serving the various operating companies in the Northern Div. of the Commonwealth & Southern Corp. With the exception of Elm Street, where a new unit was put into service last fall, the capacities shown do not include the new plants shown on Table II. The Pennsylvania Power Co. at present has no generating capacity and will continue to purchase power until the New Castle Station is in service

CONSUMERS POWER CO.	
Saginaw River Plant, Saginaw, Mich. (This does not include 7,500 kw. in house turbines)	140,000 kw.
Elm Street Plant, Battle Creek, Mich. (Includes the new 10,000 kw. unit)	50,000 kw.
Wealthy Street Plant, Grand Rapids, Mich.	37,500 kw.
Kalamazoo Steam Plant, Kalamazoo, Mich.	23,000 kw.
St. Johns Street Steam Plant, Flint, Mich.	13,500 kw.
OHIO EDISON CO.	
Toronto Station, Toronto, O. (This does not include 7000 kw. in house turbines)	140,000 kw.
Lowellville Station, Lowellville, O.	60,000 kw.
Gorge Station, Akron, O.	67,000 kw.
Mad River Station, Springfield, O.	20,000 kw.
Rockway Station, Springfield, O.	24,500 kw.
CENTRAL ILLINOIS LIGHT CO.	
East Peoria Station, Peoria, Ill. (This does not include 3000 kw. in house turbines)	46,400 kw.
Liberty Street Station, Peoria, Ill.	28,000 kw.
DeKalb Station, DeKalb, Ill.	8,300 kw.
Capitol Avenue Station, Springfield, Ill.	5,800 kw.
SOUTHERN INDIANA GAS & ELECTRIC CO.	
Ohio River Station, Evansville, Ill.	32,500 kw.
Division Street Station, Evansville, Ind.	15,600 kw.
Boonville Station, Boonville, Ind.	2,800 kw.

a pressure above atmosphere on the packing glands or between the shaft and the shaft sleeves. Past experience with this equipment has shown that the oxygen content of the feedwater can be kept at zero as determined by the Winkler test.

Boilers will be equipped with both economizers and air preheaters. The air preheaters will be provided with a by-pass so that the temperature of the metal will not fall below the dew point of the products of combustion which would be the case at the lower ratings on the boiler. Interdeck superheaters will be used and the superheat controlled by by-passing part of the gases in all but one plant. At East Peoria the temperature is controlled by reducing the superheat between the primary and secondary sections by means of by-passing a portion of the steam through cooling coils in the boiler drum.

In the high pressure additions to existing plants a reducing valve and desuperheater is provided to furnish 400 lb., 700 deg. F. steam to the old portion of the plant. The desuperheater is one developed by the company's engineering department and is extremely simple, rapid in action and maintains a constant temperature over the entire range. It consists of a steam atomizer which sprays atomized boiler feedwater into the steam to be desuperheated. The water supply is controlled by a thermostatic valve and atomizing steam is obtained from a connection ahead of the reducing valve. The operation of this equipment can be made automatic, semi-automatic or manually controlled as desired.

Auxiliary Drives

All of the auxiliaries will be driven by constant speed motors with full voltage starting. Variable speed drives for the forced and induced draft fans will be provided by variable speed hydraulic couplings. No

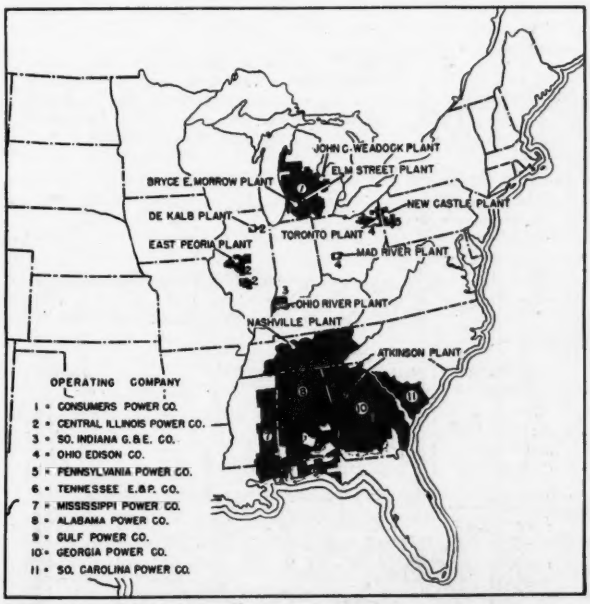

JOHN C. WEADOCK PLANT
ELM STREET PLANT
BRYCE E. MORROW PLANT
NEW CASTLE PLANT
DE KALB PLANT
TORONTO PLANT
EAST PEORIA PLANT
MAD RIVER PLANT
OHIO RIVER PLANT
NASHVILLE PLANT
ATKINSON PLANT
OPERATING COMPANY
1 • CONSUMERS POWER CO.
2 • CENTRAL ILLINOIS POWER CO.
3 • SO. INDIANA G.&E. CO.
4 • OHIO EDISON CO.
5 • PENNSYLVANIA POWER CO.
6 • TENNESSEE E.&P. CO.
7 • MISSISSIPPI POWER CO.
8 • ALABAMA POWER CO.
9 • GULF POWER CO.
10 • GEORGIA POWER CO.
11 • SO. CAROLINA POWER CO.

Fig. 2. Properties of the Commonwealth & Southern Corp. are scattered over the United States east of the Mississippi. The location of the new stations mentioned in Table II are indicated on the map and definitely identified with the operating companies. All properties lie east of the Mississippi River and the Northern Division consists of the first five on the above list

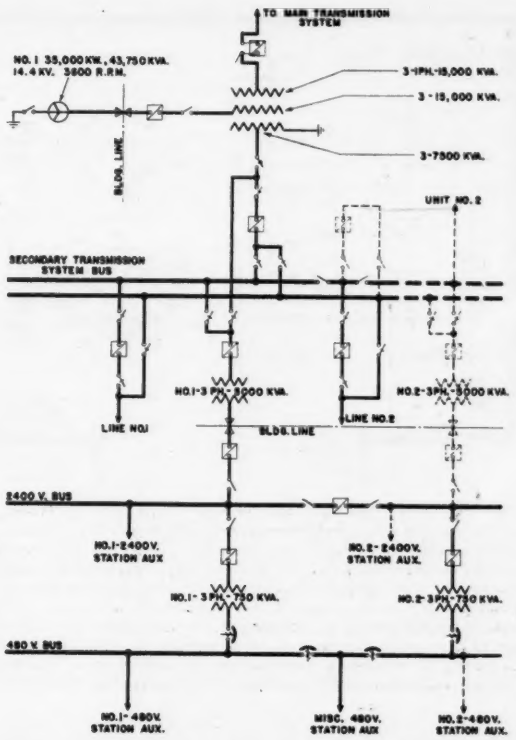


Fig. 3. Single line electrical diagram of the stations. No generator bus is used, the generator being tied directly to the low side of the main transformer and with auxiliary power taken from intermediate windings. Transmission voltages vary in the different stations. Main transmission system voltages is 140, 140 and 69 kv., and secondary system voltages 24, 46 and 24 kv. respectively for the John C. Weadock, Bryce E. Morrow and New Castle Plants

provision has been made to regulate the feedwater pressure from the constant speed boiler feed pumps. With power operated feedwater regulators this has been found to be unnecessary. A small by-pass around the regulating valve will allow enough water to pass to prevent the boiler feed pump from overheating in case the feed is interrupted.

Centrifugal or cyclone type of fly ash collectors will be provided on all of the installations. This type was adopted after due consideration of space requirements, efficiency, maintenance and cost of installation.

All of the boilers will be of the bent tube type with the furnace completely water cooled, equipped with the unit system of pulverized fuel having two mills per boiler. Several varieties of boilers and types of burners and mills will be used in the various installations. In order to reduce slagging of the boiler tubes to a minimum sufficient water wall surface has been provided to keep the average temperature of the gases entering the lower bank of tubes below the lowest ash fusion temperature of the coal to be used.

New Castle Typical of New Plants

A cross section of the New Castle Plant of the Pennsylvania Power Co. is shown in Fig. 5. This is typical of the design of the three new stations that are being built at the present time by the operating companies of the Commonwealth & Southern group. These three stations all have 35,000 kw. turbines and a single 400,000 lb. per hr. steaming capacity boiler per turbine,

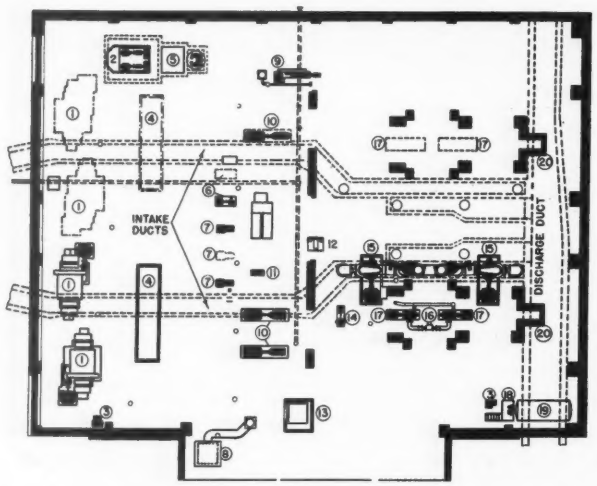


Fig. 4. Plan of the basement floor of New Castle Station. In order to have the generator adjacent to the switchhouse and transformers, the circulating water inlet tunnels were brought in under the boiler room as shown above by dotted lines. An auxiliary bay is provided between the boiler and turbine. Figures on the drawing are: 1, pulverizers; 2, ash disposal pumps; 3, oil pumps; 4, ash hoppers; 5, ash sump; 6, sluice pumps; 7, service pumps; 8, l.p. boiler; 9, air compressor; 10, boiler feed pumps; 11, evaporator pumps; 12, drip pumps; 13, elevator; 14, heater drain pump; 15, circulating water pumps; 16, condenser; 17, condensate pumps; 18, separator; 19, purifying tank; 20, turbine foundations

equipped with two ball mills and four round, turbulent type burners and dry bottom furnaces. The exterior of the New Castle Plant is shown by the headpiece at the beginning of the article.

A plan view of the same station is shown in Fig. 4. The screen house and intake will serve two units. The boiler room is located on the river side of the turbine room. This results in longer circulating water ducts but greatly simplifies the running of the electric cables underground from the turbine room to the outdoor substation located adjacent to the turbine room. A concrete stack serving two boilers is located between the intake house and the boiler room. A large steel, condensate, storage tank is built inside the base of the stack and is sufficiently large to meet the needs for all future requirements for condensate storage.

Office sections of the plants occupy a space 30 ft. by 80 ft., and several stories high. In this space are located the offices, general washroom, machine shop, electric control room, meeting room and store room for heavy stores. In the basement of the office section is located a small boiler to supply heat in case the main boiler is out of service. This boiler will only be supplied in the plants where one unit only is installed. A combined freight and passenger elevator will serve the office section and all the floors of the turbine and boiler room. This elevator operates at a speed of 300 ft. per min. and is provided with a single button collective control in order to speed up service and eliminate much of the time consumed in waiting for the elevator.

Auxiliary Bay

Space for the station power transformers, switch gear and control has been made available by adding a room between the turbine and boiler room running the length of the plant. In the basement the added room is used for feedwater heaters, pumps, miscellaneous auxiliary equipment and piping. On the operating floor, for every two main units, a small wash room is provided for the turbine and boiler room operators, thus providing additional convenient wash room facilities as the plant expands. The remainder of this space on the operating floor level and the floor above is used for the

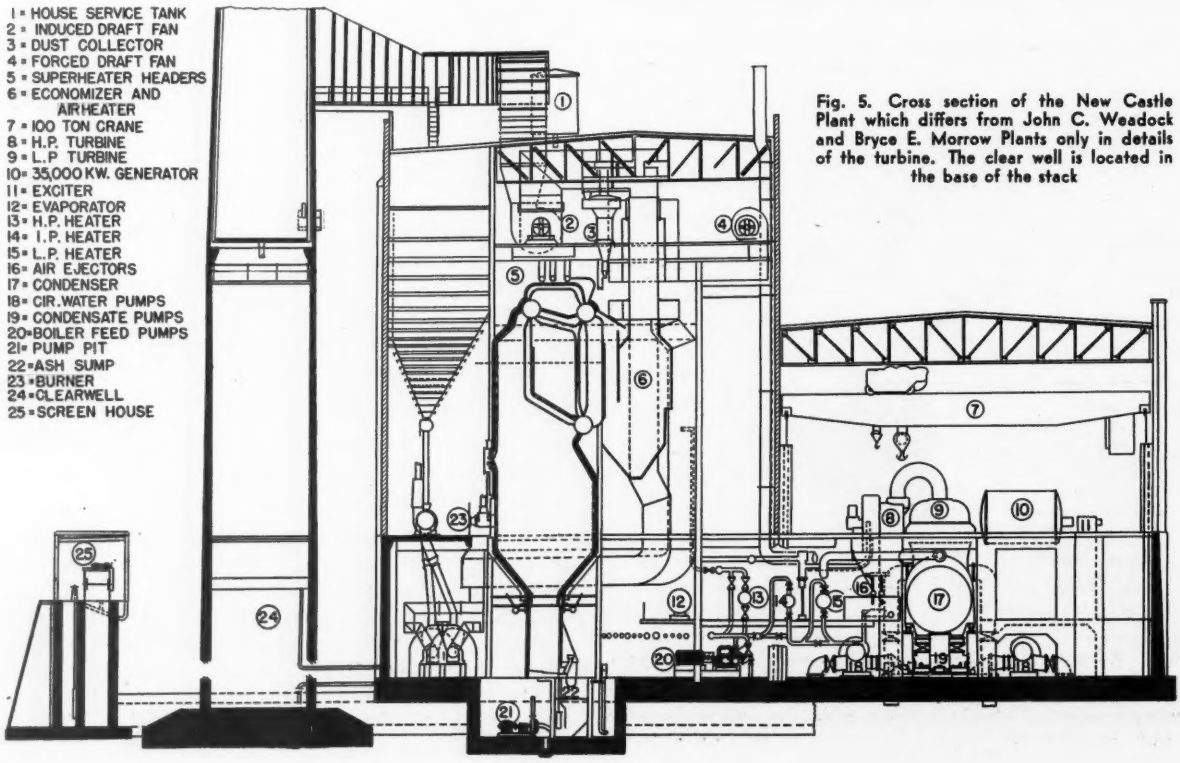

1 = HOUSE SERVICE TANK
2 = INDUCED DRAFT FAN
3 = DUST COLLECTOR
4 = FORCED DRAFT FAN
5 = SUPERHEATER HEADERS
6 = ECONOMIZER AND AIRHEATER
7 = 100 TON CRANE
8 = H.P. TURBINE
9 = L.P TURBINE
10 = 35,000 KW. GENERATOR
11 = EXCITER
12 = EVAPORATOR
13 = H.P. HEATER
14 = I.P. HEATER
15 = L.P. HEATER
16 = AIR EJECTORS
17 = CONDENSER
18 = CIR. WATER PUMPS
19 = CONDENSATE PUMPS
20 = BOILER FEED PUMPS
21 = PUMP PIT
22 = ASH SUMP
23 = BURNER
24 = CLEARWELL
25 = SCREEN HOUSE

Fig. 5. Cross section of the New Castle Plant which differs from John C. Weadock and Bryce E. Morrow Plants only in details of the turbine. The clear well is located in the base of the stack

station power transformers, switch gear and control. Of the two remaining floors in this section one will be used for laboratories and the other for general stores.

The 3600 r.p.m. 35,000 kw. generators will be hydrogen cooled. Cooling water for this purpose and for general house supply will be taken from shallow walls, wherever the soil conditions are suitable for obtaining a sufficient supply which will insure colder and cleaner water than the circulating water can supply.

conveyor. For the plants of larger ultimate capacity, a traveling tripper will be used which will discharge the coal into the bunkers through sealed slots, which will be made as dust tight as possible. A ventilating system taking air from the top of the bunkers and discharging through a dust collector will, it is believed, make these installations reasonably dust free even with the negative pressure generally existing at the top of the bunkers and boiler room.

Table II. Principal data on the seven plants covered by the building program of the Northern Div. of The Commonwealth & Southern Corp. The station design heat rates for best load and 29 in. of vacuum are about 12,000 B.t.u. per net kw. hr.

OPERATING CO.	STATION	LOCATION	THROTTLE PRES. LB./SQ"	THROTTLE TEMP. °F.	BOILERS NO.	BOILERS CAPACITY LB./HR. EACH	BOILER SQ. FT.	SUPERHEATER SQ. FT.	SUPERHEATER T. CONTROL	ECON SQ. FT.	AIR HEATER SQ. FT.	AIR HEATER TYPE	FLY-ASH COLLECTOR	W.W. SQ. FT.
NEW PLANTS														
CONSUMERS POWER CO.	JOHN C. WEADOCK	BAY CITY, MICH.	600	850	1	400,000	7448	9450	BYPASS DAMPER	28,512	54,100	TUBE	TUBE & CYCL.	4078
	BRYCE E. MORROW	COMSTOCK, MICH.	600	850	2	400,000	7448	9450	BYPASS DAMPER	28,512	54,100	TUBE	TUBE & CYCL.	4078
PENNSYLVANIA POWER CO.	NEW CASTLE	NEW CASTLE, PA.	600	850	1	400,000	7448	9450	BYPASS DAMPER	28,512	54,100	TUBE	TUBE & CYCL.	4078
TOP OR PLANT EXTENSION														
CENTRAL ILLINOIS LIGHT CO.	EAST PEORIA	PEORIA, ILL.	600	850	1	300,000	14,740	7850	DESUPERHEATER	5800	43,500	TUBE	TUBE & CYCL.	10,000
CONSUMERS POWER CO.	ELM STREET	BATTLE CREEK, MICH.	600	850	1	360,000	4134	10,480	BYPASS DAMPER	——	67,733	TUBE	TUBE & CYCL.	6254
OHIO EDISON CO.	MAD RIVER	SPRINGFIELD, OHIO	600	850	1	225,000	6150	7200	BYPASS DAMPER	14,100	22,500	PLATE	TUBE & CYCL.	4235
SO. IND. G. & E. CO.	OHIO RIVER	EVANSVILLE, IND.	600	850	1	225,000	5320	6760	BYPASS DAMPER	14,580	26,080	TUBE	TUBE & CYCL.	3010

STATION	FURNACES VOL. CU. FT.	FURNACES H.REL'S B.T.U./CU.'	FURNACES TYPE BOT	FURNACES TYPE FIRING	AUXILIARIES F.D. FANS NO.	F.D. FANS C.F.M. EACH	F.D. FANS IN H_2O	F.D. FANS °F	I.D. FANS NO.	I.D. FANS C.F.M. EACH	I.D. FANS IN H_2O	I.D. FANS °F	GENERATING UNITS NO.	RATING KW.	SPEED R.P.M.	B. PRES. LB./SQ" ABS.	COND'SR SQ. FT.	GEN. COOL.
JOHN C. WEADOCK	21,950	24,300	DRY	PULV. COAL	1	130,000	11.8	100	1	215,000	14	300	1	35,000	3600	0.63	33,000	HYD.
BRYCE E. MORROW	21,950	24,500	DRY	PULV. COAL	1	130,000	11.8	100	1	215,000	14	300	2	35,000	3600	0.63	33,000	HYD.
NEW CASTLE	21,950	24,500	DRY	PULV. COAL	1	130,000	11.8	100	1	215,000	14	300	1	35,000	3600	0.63	33,000	HYD.
EAST PEORIA	19,700	21,000	DRY	PULV. COAL	1	100,000	10	100	1	170,000	13	330	1	25,000	3600	0.63	21,400	AIR
ELM STREET	19,830	22,700	DRY	PULV. COAL	1	105,000	10.5	100	1	190,000	12.25	350	1	10,000	3600	225	——	AIR
MAD RIVER	——	29,600	DRY	PULV. COAL	1	75,000	9.5	100	1	125,000	12.5	300	1	20,000	3600	0.63	18,200	AIR
OHIO RIVER	12,300	25,200	DRY	PULV. COAL	1	75,000	10	100	1	125,000	11.5	325	1	20,000	3600	0.63	18,300	AIR

Current will be generated at 14,400 v, and is stepped up for transmission through three winding transformer banks to voltages of either 24,000 or 46,000 v., and to either 69,000 or 140,000 v. Each generator feeds directly into its transformer bank, there being no common generator bus. In general the station power supply is taken off of the intermediate voltage of the transformer bank at either 24,000 or 46,000 v., and is stepped down through a transformer bank to the 2400 v. station power bus which has bus tie breakers between each unit. Motors from 100 hp. and above are connected to this bus and are started with full voltage. From the 2400 v. station power bus another transformer bank is used for each unit stepping down to a 480 v. bus, which, like the 2400 v. bus, has switching facilities between bus units. Motors below 100 hp. are supplied from this bus. A single line diagram showing the general electrical system, which has been briefly described above, is shown in Fig. 3.

Coal Handling

Coal handling equipment varies in the different plants depending upon local conditions and upon the ultimate size. Every effort has been made to make the coal handling as dustless as possible. Inclined belts will deliver the coal to the top of the bunkers, which are covered, and the coal distributed by scraper conveyors, totally enclosed, for those plants whose ultimate capacity is within the capacity of this kind of

This article covers in a very brief manner some of the features of the design of the various plants being built or designed for the operating subsidiaries of the Commonwealth & Southern Corp. Many details of design vary for the different plants due to preference of the local operating personnel or local conditions, but it will serve to indicate the trend in power plant design as practiced by this company.

District Heating Costs

Keeping investment and other fixed charges low enough so that district steam can, in spite of its low annual load factor, compete with the isolated plant, is a permanent problem of the district heating utility, said D. S. Boyden, national president of the American Society of Heating and Ventilating Engineers, in an address before the New York Chapter. A modern district heating system has an over-all thermal efficiency of 63 per cent compared with efficiencies of 50 per cent for small isolated heating plants and 60 per cent for medium size plants.

Investment in a district heating plant is from $2 to $4 per pound of steam capacity and of this the cost of the distribution lines is from 70 cents to $1.35. Cost of installing a 12 in. main underground runs about $37.32 per lineal foot. This is made up of: $9.08 for pipe, valves and fittings; $4.84 for insulation; $5.06 for excavation and filling; $3.29 for concrete work; $6.25 for paving; $3.50 for engineering, and $5.30 for extras.

MODERN TURBINES*

Have you ever tried to calculate the heat content, superheat or moisture in your turbine exhaust at different loads for engineering or cost accounting purposes? Have you been up against the problem of finding out what a different throttle pressure and temperature or a change in back pressure would do to the load you can carry with your boilers? If you have been up against this your troubles are over. This month Mr. Newman tears the basic steam flow-output chart up in pieces and show you how to put it together in a dozen different ways. With this article, a slide rule and Mollier chart you can make your turbine turn handsprings and tell just where it will land each time.

By
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Lynn, Massachusetts

PRICE AND PERFORMANCE are the Siamese Twins of a power plant. Either one without the other is meaningless. From inception to completion of any power plant these "twins" will be found inseparably linked together. They will be met in preliminary studies when comparisons are made between the performance of extraction type turbines and performance of the less costly non-extraction turbines. Later, competitive bids will be evaluated on the basis of price and performance. Finally, when the turbine has been installed, the operator will study the different performance charts of each of his several turbines to determine how the load should be divided between them in order to generate power at the lowest possible fuel cost. Always it is price and performance; price alone can never be the sole criterion.

Prices are relatively easy to understand. Performance is more complex, so time should be spent in becoming familiar with various expressions for turbine performance. Interesting relationships between different types of performance charts should be seen. Something should be learned of the derivation of the basic types of charts and much should be known about how to use them. Only then can proper weight be given to performance when considered with price.

Purchasers of turbines usually insist on knowing "how much steam they must supply to the turbine." Sometimes they ask "how hot will the steam be when it leaves the turbine?" And occasionally they are interested in "what can be expected when the turbine is operated with other than its normal steam conditions." The three different types of expressions needed to answer these questions are:

a. Total quantity of steam flow, or steam rate, required for different outputs.

b. Temperature, quality, or heat content of steam leaving the turbine.

c. Variation of steam flow, or output, with change in steam conditions.

Of these, the first (discussed in detail last month) is most important. The other two may usually be derived from the basic throttle steam flow vs. output performance chart of which Fig. 1 is an elemental form. All of the different expressions for turbine performance have important uses, however, and a brief review of some of these uses, will show how the different forms are related to each other and how they are derived.

If for example, you were faced with the problem of laying out a new power plant, or reconditioning an old one, you would carefully study throttle steam flow vs. output charts for each of several combinations of turbines. These charts would guide you in selecting optimum steam pressures and temperatures. They might have great influence on your choice of the most economical turbine type and rating, for with these variables determined, you would rely again on the steam

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BEFORE the author of this series steps aside for J. M. Lyons' interesting and informative articles on the generator part of a turbine generator set (which will begin in the April issue and run as an integral part of the series under the same title, Modern Turbines) he wishes to acknowledge his debt to two able critics. A. D. Somes and Allen Keller, both of the Turbine Engineering Dept., General Electric Co., Lynn Works, have checked the technical accuracy of each article and many times have given invaluable advice in clearifying obscure explanations.

flow vs. output charts to furnish the performance data necessary to make comparisons between competitive turbines. Probably you would investigate the designs of those turbines to see which would sustain its high economy over a period of years. In arriving at evaluated prices, weight would be given reliability, service facilities, and perhaps some intangibles, but the chances are that attention would be focused primarily on the steam flow vs. output charts.

Throughout the long life of the turbine the Operator will have a like interest in these charts. They will guide him in apportioning load between several turbines; they will show which turbines may be operated most economically and which should be held for stand-by. Other types of performance charts may be useful to him but rarely will they occupy the position of importance held by throttle steam flow vs. output charts.

But there are applications where the other types of performance charts become of great value. When, for example, steam is exhausted into heating lines it is important in many cases to know how much heat is in the steam fed these lines. This would be valuable information if its only use were to figure how much of the cost of fuel should be charged against the production of power, and how much against building heating or process. Information enabling you to relate price and performance in this way may be obtained from charts of heat in exhaust steam vs. output; a type of chart, which, as will be shown later, you can readily estimate.

Another useful application of performance charts of this type are in those cases where a new high pressure noncondensing turbine is superposed on an existing plant. The old turbines will be limited to some maximum safe temperature, and you can refer to a chart of the same type, except plotted as exhaust temperature vs. output, to be sure that safe limits will not be exceeded. And so it goes with numerous other applications for this type of chart, even extending to furnishing information on which the choice of boiler pressure and initial temperature are based.

And, last of all, you may want to know what will happen to the basic steam flow vs. output chart, Fig. 1, when the steam conditions depart from normal. What decrease in throttle flow should you expect, for example, when the turbine is operated with improved vacuum associated with winter time cooling water temperatures? How much increase in steam flow might be expected when, under emergency conditions, the steam pressure drops below normal? What gain will result from dropping the extraction pressure below its design pressure? These and kindred questions all can be answered by charts which, you can derive, giving corrections to be applied to the basic steam flow vs. output chart when the turbine is operated with steam conditions other than normal.

Basically, each of these different types of performance charts has its roots imbedded in the familiar steam flow vs. output chart. How they may be obtained from the basic chart is often not obvious. Once we have seen how they are derived, what they look like, and how they can be used we will be in a better position to correlate the "twins," price and performance.

Condition of Steam Exhausted

Whenever the steam exhausted or extracted from a turbine is used again for power or heating, it is often of value to know its "condition" at the point it leaves the turbine. How the steam will be used will determine whether its condition should be expressed in terms of *temperature, heat content, or quality.* These three forms of performance charts may be derived from the familiar steam flow vs. output chart, Fig. 1, and any one of the three forms may be readily converted to one of the other forms.

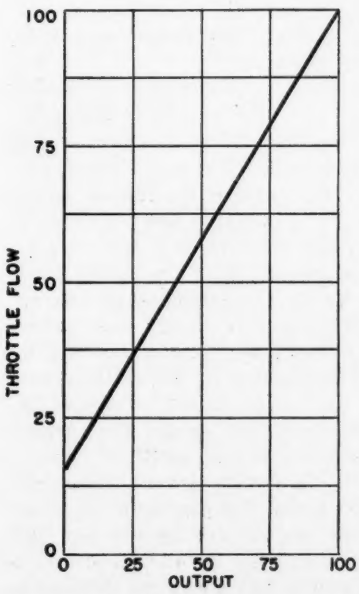


Fig. 1. Throttle flow vs. output forms a basic chart for evaluating turbine performance. This is the same as Fig. 1 of the previous article in the February issue

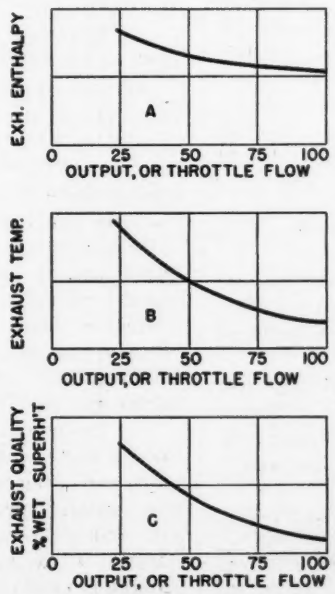


Fig. 2. The condition of steam exhausted from a turbine may be expressed in several ways and plotted against output or throttle flow as shown by the three charts above

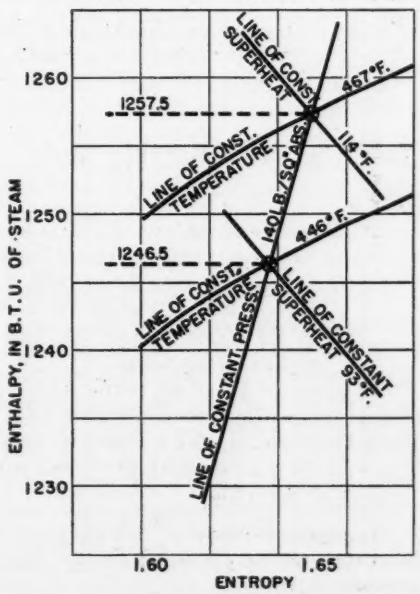


Fig. 3. Section of a steam chart showing how enthalpy, temperature, pressure, superheat, steam quality and entropy are related and how to determine all with any two given

There are numerous forms of these charts relating the condition of steam leaving various types of turbines with the output or steam flow. But if one has a clear understanding of the appearance and derivation of these charts for noncondensing turbines there will be no difficulty in using similar charts for extraction turbines. So we will study the typical forms of these charts for noncondensing turbines as illustrated in Fig. 2A, B, and C, and if our study has been made with sufficient care we will not only learn much about these charts but will enrich our fundamental understanding of what happens to the heat energy inside the turbine.

Figure 2A can be quickly approximated for any

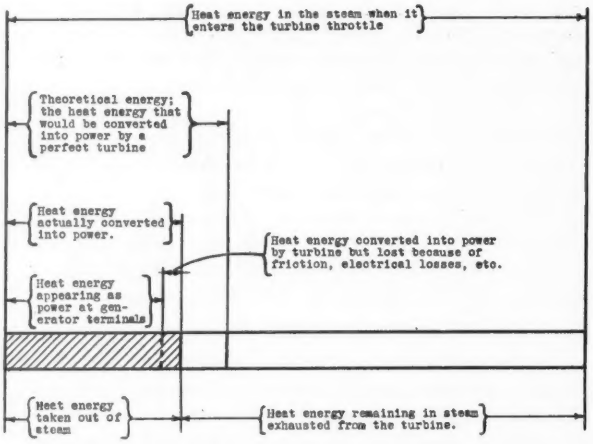

Heat energy in the steam when it enters the turbine throttle
Theoretical energy; the heat energy that would be converted into power by a perfect turbine
Heat energy actually converted into power.
Heat energy converted into power by turbine but lost because of friction, electrical losses, etc.
Heat energy appearing as power at generator terminals
Heat energy taken out of steam
Heat energy remaining in steam exhausted from the turbine.

Fig. 4. Diagram showing the disposition of heat energy in the steam which flows to the turbine

50- or 60-cycle straight noncondensing turbine-generator set rated not less than 500 nor more than 7500 kw. by using the following simple formulae:—(see footnote[1]):

Heat content of exhaust steam at 100 per cent load = initial enthalpy—(3600 ÷ full load steam rate).

Heat content of exhaust steam at 50 per cent load = initial enthalpy—(3700 ÷ one-half load steam rate).

In symbol form this equation is:—

$$H_f = h_o - \frac{F}{S} \qquad \text{(Eq. 1)}$$

where,

h_f is the enthalpy[1] of steam exhausted
h_o is the enthalpy[1] of steam initially
F is the final heat factor, which at 100 per cent load is 3600 and at 50 per cent load is 3700
S is the steam rate at the load corresponding to final heat factor.

An example based on performance previously estimated (page 741 of the December 1937 issue of Power Plant Engineering) for a 2000-kw. noncondensing turbine will show how easily the formula may be used.

Rating: 2000 kw.

Steam conditions:—600 lb. per sq. in. ga., 700 deg. F. total temperature, and 125 lb. per sq. in. ga. exhaust pressure.

[1]The term "enthalpy" used in these equations, is defined as the heat content, in BTU per lb. of steam, above the heat content of water at a temperature of 32 deg. F. Formerly "enthalpy" was loosely called "total heat", which is more properly the heat content of steam above absolute zero.

Estimated Steam Rates determined as outlined in the article beginning on page 741 of the December 1937 issue of Power Plant Engineering.

Output, in kw.	Steam rate, in lb. per kw. hr.	Exhaust enthalpy, in B.t.u. per lb.
2000	34.8	1246.5
1000	40.0	1257.5

The initial enthalpy of the steam, h_o of Eq. 1, in this case 1350, may be read from any steam chart, or steam table. Estimated heat content (enthalpy) of exhaust steam at 2000 kw. is then

1350—(3600 ÷ 34.8) or 1246.5 B.t.u. per lb.

and the estimated enthalpy of exhaust steam at 1000 kw. is

1350—(3700 ÷ 40.0) or 1257.5 B.t.u. per lb.

But suppose that the heat remaining in the exhaust steam is a form of expression not as convenient for your purposes as the temperature or superheat in the steam exhausted. If this is so you need only refer to a steam chart (or steam table) and read the temperature or superheat corresponding to the exhaust pressure and enthalpy. In Fig. 3 is sketched a section of a steam chart showing by this example that at a given steam pressure and enthalpy there is a definite temperature and a definite quality or superheat. So we can tabulate.

	Condition of Exhaust Steam		
Output in Kw.	Enthalpy B.t.u. per lb.	Temp. deg. F.	Superheat deg. F.
2000	1246.7	446	93
1000	1257.7	467	114

The significance of this is that *performance charts of enthalpy, temperature or quality are really all one and the same thing,* easily convertible from one form to the other.

Probably the easiest way to understand what we have done and why our simple formula gives close approximations of exhaust condition, is to get a clear picture of what happens to the steam after it enters a turbine. Figure 4 is a chart showing the disposition of heat energy in each pound of steam from the time it first enters the turbine to the time it is exhausted.

As shown by Fig. 4, steam passes through a turbine undiminished in weight, but each pound of steam exhausted has had some of its original store of heat energy removed. If the turbine were an ideal one, 100 per cent efficient, the heat energy remaining in the exhaust steam would be equal to the initial enthalpy less the theoretically available heat energy. No turbine is 100 per cent efficient; no turbine can convert all of the energy theoretically available into power. But turbines do convert a sizeable portion of the available energy into power. The heat energy they convert into power is taken out of the steam and the heat remaining in the steam passes out the exhaust. When the turbine takes heat energy out of the steam and converts it into power, the turbine doesn't know how this power will be used.

Power developed may be used to drive a paper machine, a ship's propeller, a pump, a generator, or whatnot. But whatever it drives will not be 100 per cent efficient. If, as in the usual case, the turbine drives a generator, most of the power, but not all of that delivered by the turbine, will reappear as electrical energy. Some will have been used to drive the turbine's own oil pump, some will be dissipated as heat in the bearings, and

some as generator losses. But the important thing is that the *steam* doesn't know this. From the steam's standpoint some of its heat energy has been converted into power. The only heat remaining in the steam is the heat that was not converted into power *inside* the turbine. So in determining how much heat is left in the steam exhausted from a turbine, it is only the *internal* efficiency that counts.

But the performance of turbine generator sets is not often expressed on the basis of the turbine's internal efficiency. It is of interest to the designer, but users care only about the *overall* performance. So performance is expressed in terms of how much steam will be required to give a net power output at the generator terminals. In Eq. 1 the "final heat factor" converts *overall* efficiency to *internal* efficiency, thus giving an approximation of the true quantity of heat energy remaining in the exhaust steam.

Let's go one step further and translate what has been said to terms of the steam chart. Familiarity with the steam chart will enable you to solve easily many otherwise perplexing problems, so each time we can talk in terms of it our understanding of the steam chart increases. Using the previous example of the 2000-kw. noncondensing turbine, a section of a steam chart has been drawn in Fig. 5. Point A on this chart gives the initial enthalpy of the steam. Its position was determined by the intersection of the line representing the initial pressure, 615 lb. per sq. in. abs. (600 lb. ga.) with the line representing the initial total temperature of 700 deg. F.

In an ideal turbine the energy available for power would be determined by *dropping vertically down* (at constant entropy) to the exhaust pressure of 140 lb. per sq. in. abs. (125 lb. ga.). Then the energy represented by AB would be that theoretically available for power in an ideal turbine having an internal efficiency of 100 per cent. And at the point B the heat energy remaining in the exhaust of a perfect turbine could be read.

In an actual turbine, point C[2] represents the true heat energy remaining in the steam exhausted. Its position (full-load condition for this example) was determined from Eq. 1 by subtracting the actual heat energy taken out of the steam from the heat energy initially in the steam. Point C is the intersection of the line representing the exhaust pressure with the actual final exhaust enthalpy. Note that this intersection can occur at only one point and that at this point the steam has a definite temperature and a definite superheat or quality. At a given pressure as soon as any one of the variables heat content, temperature, or quality is fixed the other two are fixed. Because of this a performance chart expressed in terms of one of the variables may be quickly converted to one of the other variables.

What we have said applies specifically to noncondensing turbines, but may be broadened to apply to any type of turbine. An extraction turbine, for example, would have a temperature of extracted steam chart similar in appearance to Fig. 2B. However, charts of the steam's condition at the extraction openings of extraction turbines may not be as readily approximated from the steam flow vs. output chart as we were able to do for straight noncondensing turbines. When such charts are needed they should be obtained from the manufacturer.

[2]Line AC is known as the "state" line. From it the state of the steam at any pressure between inlet and exhaust may be determined.

A clear picture of the various forms of charts for expressing the condition of steam exhausted from noncondensing turbines is important, and will enable you to make good use of similar charts for other types of turbines. When these charts are understood, price and performance may be more easily correlated.

Correction Charts

Correction charts are less important than either the steam flow vs. output performance charts, or the charts giving the heat remaining in steam extracted or exhausted. But they are easy to understand and deserve brief study. When, for example, a turbine is required to operate for any length of time with steam conditions other than normal, expected steam flows at the changed conditions may be obtained by correcting the steam flows

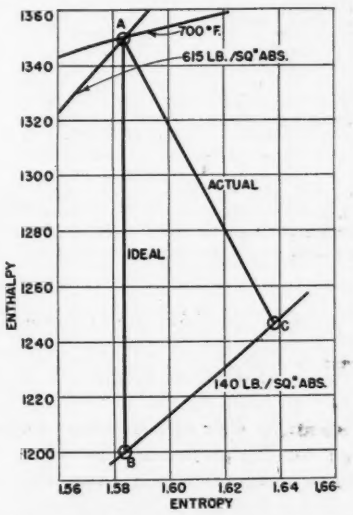


Fig. 5. Section of Mollier chart showing the expansion lines of an ideal and an actual turbine. The ratio of AC to AB is a measure of the efficiency of the turbine. The difference between the enthalpy at Points C and B is the additional heat which an ideal turbine would convert into power but which an actual turbine rejects in the exhaust

at the normal conditions to the new steam conditions. The corrections to be applied to the steam flows at the normal steam conditions are usually expressed in the form of charts which may be either of two general types; *multiplying* factors, Fig. 6, or *increment additions*,[3] Fig. 7.

Usually these charts give the corrections to be applied to guaranteed performance to obtain expected performance with other than normal steam conditions. A reciprocal form of these charts is sometimes requested when "test" results at test steam conditions are to be corrected to the same basis as the performance guaranteed with normal steam conditions. This latter form of chart does not have the every day direct utility of the other charts, for tests are only run at infrequent intervals. At other times, when performance expected at some changed condition is needed, it would be necessary to read the corrections; then apply them by *dividing* when the correction chart indicated *multiplication*, or *subtract* when the chart indicated *addition*. Because the greatest

[3]On actual charts of this type pressures, superheats and flows are expressed in their common units rather than as percentages.

utility of any correction chart will be in the field of regular operation and not in the field of proving guarantees by tests we will limit this explanation to the type of chart from which expected performance at any set of operating steam conditions may be directly obtained by correcting the performance guarantees to the new conditions. (By a reverse process charts of this type could be used for test corrections.)

Correction charts of the multiplying factor type, Fig. 6, have been in more common use than the increment addition type, Fig. 7, but it is probable that the increment addition type will become increasingly more important. Both forms are easily used, however, and it is

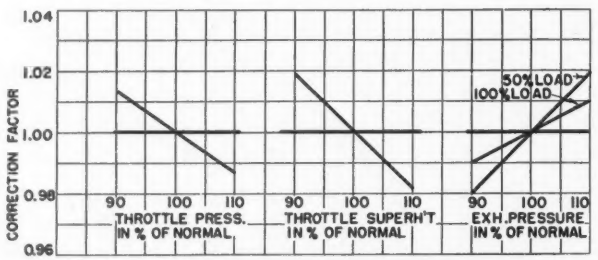


Fig. 6. Appearance of a typical multiplying factor type of correction chart. To obtain steam rates, or steam flows, at other than normal steam conditions, from a chart of this type multiply normal condition steam rates or steam flows by the correction factor for each of the changed conditions

ordinarily wise to let the manufacturer choose which form better fits each specific request. To use the multiplying factor type, such as illustrated by Fig. 6, it is only necessary to multiply the steam rates at the normal steam conditions by each of the factors corresponding to the changed throttle pressure, superheat, and exhaust pressure. The resultant steam rates will be those expected when the turbine is operated with the changed steam conditions. Charts of the multiplying factor type could be used for any type of turbine, but the form of the chart becomes relatively complex when accurate corrections to extraction turbine performance are required. For extraction turbines the increment addition type of correction chart is more easily used and can be expressed with greater accuracy in much simpler form.

Increment additions from correction charts of the form illustrated by Fig. 7 are ordinarily in terms of the change in throttle flow resulting from a change in any or all of the steam conditions affecting the steam flow. They could be, and sometimes are, expressed in terms of change in steam rate or output resulting from a change in any of the normal steam conditions.

To obtain expected performance at other than normal steam conditions from the increment addition type of correction chart it is only necessary to obtain, from the correction chart, increments (positive or negative) to be added to any selected throttle flow at the normal conditions. When these additions are made to the selected throttle flow the resultant throttle flow will be that expected when the turbine is operated with the changed steam conditions.

Except for minor changes in efficiency, correction charts are derived from Fig. 1, the basic throttle steam flow vs. output chart. It will be recalled that there is a different quantity of energy theoretically available for power between different sets of initial and final steam conditions. By taking these differences in available energy, correcting them for slight changes in efficiency, and applying them to the basic performance chart it is possible to cover a wide range of steam conditions.

That correction charts for variation in steam conditions are needed, is one more evidence of the flexibility of steam turbines. Not only can they be designed for initial steam pressures ranging from atmospheric to over 2000 lb. per sq. in., and for a wide variety of applications, but turbines can be successfully operated with steam conditions departing far from their normal design conditions. It should be understood, however, that a turbine designed for one set of steam conditions may not be suitable for operation with the new steam conditions desired unless the proposed operation was taken into account in the original design. Each turbine has limits of pressure, temperature, and stress, beyond which it may be safe to operate. So before a turbine is operated with steam conditions other than those for which it is designed the manufacturer should be consulted.

Linking Price with Performance must involve more than a simple comparison of differences between two turbines. Performance initially guaranteed is one factor but equally, or more important, than this factor is the ability of the turbine to sustain its original level of efficiency over a long period of years. If high maintenance charges are required to maintain the initial level of efficiency this must be considered in the evaluated price. If high efficiency is obtained at a sacrifice in reliability some weight must be given this in the evaluated price. If differences in service facilities are pronounced some measure of their worth should be put into the price.

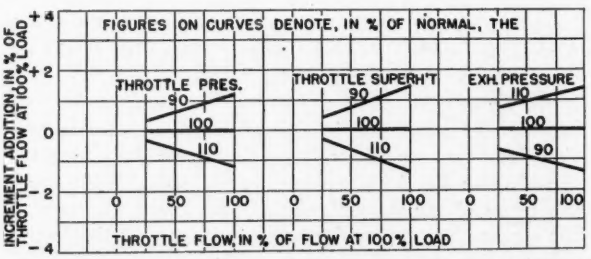


Fig. 7. Corrections to steam flow or steam rate for other than normal steam conditions are sometimes given by a chart of this kind known as the increment addition type. Here the steam flow for the changed condition is found by adding to, or subtracting from, the throttle flow for normal conditions the proper increment for each of the changed conditions. Pressures and superheats are given above as a per cent of normal but on actual charts for specific turbines they are given in their customary units of pounds per square inch and degrees Fahrenheit

Whether all of these and kindred factors are weighted on the basis of an actual evaluated price, or summed up in the purchaser's mind makes little difference. To one engineer actual figures are convincing; to another his broad experience points the proper direction. But always considerations of turbines involve price and performance; price from the longtime standpoint of quality and reliability; performance from the standpoint of meeting all requirements initially and maintaining this high level of performance throughout the years of service. Then both price and performance are considered together in a critical analysis of the best long term investment in apparatus to generate low cost power.

Fighting Cooling Pond Algae

Troublesome Scum in Cooling Water Supplies is Not Difficult to Combat if the Engineer knows how to do it

By Elton Sterrett

DEVELOPING almost overnight from scattered patches in a cooling pond to a thick scum which obscures the surface, algae, generally called pond scum, indirectly cause many internal combustion engine failures through impaired cooling systems. The actual damage, ranging from a burned out main bearing to a scored cylinder or seized piston, may be traced directly to insufficient cooling through stoppage of water lines or the increase in inflow water temperature caused by choked pond area.

Appearing first as small greenish patches on the surface of the water where least disturbed by wind and current the algae spread almost magically under favorable conditions of light, temperatures and air. The slimy masses block off the surface of the water, prevent evaporation or radiation from the surface, and so increase the temperature of the water below. As the growth progresses, these masses are drawn into the suction lines, clogging pump ports and forming blocking plugs in the narrower spaces inside the engines, with destructive results.

Skimming the algae from the surface of the pond is of little value, as there are ample centers left afloat to quickly cover the surface again. Even though the water supply be drawn from an artesian well or other source free from contamination, it is only a question of time until wind borne spores reach the surface and again the spidery network characteristic of the earlier stages of algae appear. Where the cooling water is pumped through a cooling tower, as in the usual closed system with make-up water added to replace evaporation losses, the growth of algae quickly overruns the diversion trays, causing channeling of the flow and rapid decay of the structure.

The U. S. Department of Agriculture has done extensive work in connection with algae control, finding that different species vary widely in their reaction to controlling agents. Of the commoner types found, Uroglena, for instance, is destroyed by only 0.4 p.p.m., while Baggiatoa survived until the proportion reached 41.5 p.p.m. Since the average power plant engineer is unable to determine the scientific classification of the algae, and even many chemists specializing in water problems are equally unable to identify all kinds, the usual plan is for the engineer to proceed on the supposition that his pond is host to the vigorous Baggiatoa, and to treat his water supply accordingly. At one plant where algae growth was especially prevalent, due to a nearby marsh which provided prompt reinfestation after treatment, make-up water for a cooling system serving a battery of six 400-hp. internal combustion engines was kept in a concrete pit 50 by 20 by 10 ft. in size, holding, when full, approximately 78,000 gal. of water. To eliminate Baggiatoa from this quantity of water would, according to U. S. D. A. recommendations, require almost exactly 3 lb. of commercial copper sulphate. Following the usual plan for applying this material, it was put into a loosely woven sugar sack and lowered to the bottom of the pool. Results were far from satisfactory, and the masses of algae disappeared slowly. For the next treatment the required chemical was dissolved in 7.5 gal. of water and sprayed over the surface of the pond. In one-third the time formerly required the surface was practically free of scum.

Following this improvement a series of experiments were run by the plant engineer in which the pit was first treated as per U. S. D. A. specifications with a solution containing 3 lb. of copper sulphate, both solution and pit temperatures being checked at 80 deg. F. On successive fillings of the pit, the temperature of the solution was varied by 20 deg. F. amounts above and below that at the surface of the pool.

At a temperature 80 deg. F. above that of the water, or 160 deg. F. for the solution, it was found that a 7.5 gal. solution containing only 1.1 lb. of copper sulphate was completely effective at the top of the pool, though a sample drawn from a foot off bottom showed that the concentration of the chemical there was only 18 per cent that obtained at the surface. These test results are plotted on Fig. 2.

Since algae are surface growths, their mass being almost entirely confined to the upper layer of water in a pond and the concentration decreasing rapidly with the depth at which the sample is taken, it is evident that surface application of the controlling agent is to be desired. This will clear the upper portion of the body of water without wasting solution in treating the uncontaminated bulk lying deeper down.

Following his discovery that the application of hot solutions, tending to spread thinly and rapidly over the surface because there is no tendency toward vertical diffusion through the establishment of thermic circulation, is most effective, the engineer enlisted the aid of a nearby water supply chemist for laboratory determinations, and concentrations were checked at each foot mark on the gauge below the surface.

Fig. 1. In a pit of this size 10 ft. deep one pound of chemical heated in solution will do the work of three pounds dumped into the water

Although it would be reasonable to expect that the heavier fluid of the copper sulphate solution would gradually mix with and descend through the water in the pit, careful checks after 24 hr. showed that the concentration remained stronger at the surface, decreasing with depth to give a bottom concentration less than one-fifth that found at the surface. If this heavier treating solution must diffuse upward through a body of water, as is the case with bottom applications of undissolved chemicals, the effective protection obtained against algae is greatly reduced as compared with that obtained by applying a relatively hot, and consequently lighter, solution at the surface.

Where open concrete pits or uncovered tanks are used for make-up or cooling water storage, formation of clogging masses of algae is greatly retarded if, after

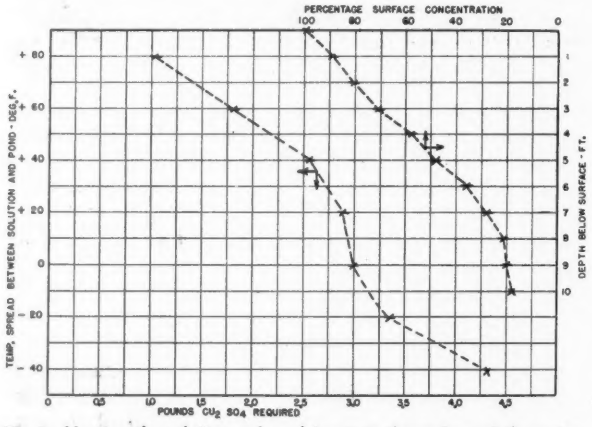

PERCENTAGE SURFACE CONCENTRATION
100 80 60 40 20 0
TEMP. SPREAD BETWEEN SOLUTION AND POND - DEG. F.
DEPTH BELOW SURFACE - FT.
POUNDS CU_2 SO_4 REQUIRED

Fig. 2. Heating the solution and applying it to the surface of the water is effective in reducing the amount of chemical required. Tests plotted in the upper right hand corner show that a properly applied solution diffuses downward slowly even after 24 hr.

each draining, the walls and bottom of the container are scrubbed with a stiff broom dipped in a one per cent solution of copper sulphate. This precaution insures a thorough treatment for the active sections of scum left in the interstices and deposited over the rough surfaces swept by the surface of the water as the pit is drained, thus leaving the new supply of water open to contamination only through air-borne spores.

While some of the chemicals used for preventing scale formation, or for converting it to a less harmful form, are also effective against algae, it is not safe to consider that they will give the desired results. The water purifiers which act mechanically, such as tannin, carry a part of the algae with them, but a tannin-treated body of water is no more immune to outside contamination than one fresh drawn from other uncontaminated source.

Sodium dichromate ($Na_2Cr_2O^7$) is sometimes used to combat scale formation in cooling systems, and is effective against algae, sufficient to clarify the scale formation being ample to keep down the growth of algae. But, used for algae control alone, the chemical is much more expensive than the more common copper sulphate which, under its common name of bluestone or blue vitriol, may be secured through any drug store in any quantity required.

In completely closed cooling systems, where pond or other surface water is sprayed or flowed over coils carrying the actual coolant, the formation of masses of algae again finds congenial surroundings, and the supply must be treated if the coils are not to become buried in heavy masses of scum, tenacious enough to resist washing away by the sprays, and thick enough to cut off all cooling by air.

Since copper sulphate is poisonous to animal life if in sufficient concentration any efflux of water which has been treated for algae removal must be closely watched and pits or other storage emptied only when there is sufficient flow in the stream to which it is run to insure thorough dilution of the poison. If a stream for carrying away the water is not available, open pits may be used, in which the dilute copper sulphate solution may be run and allowed to evaporate under the effect of sun and wind. When evaporation is complete the earth may be spaded up or a thin skim shoveled from it to prevent the deposit of copper sulphate from being later carried away by surface flow of rain water.

As a basis for scum elimination work, a plant engineer is safe in applying a solution of copper sulphate, in U. S. D. A. strength, to his water supply. Action may be speeded and amount of chemical reduced by heating the solution and applying it as near the surface of the pond as possible, dividing the total application into a number of smaller lots and spacing these evenly around the edge of the water supply. Then, after applying the first solution, he may be guided in further prevention and cure of scum formation by the percentages, quantities and temperatures shown in the accompanying curves.

Strength of Concrete

VIBRATING the concrete in a pavement as it is laid increases the strength 10 percent, according to a report by the Bureau of Public Roads of the U. S. Department of Agriculture or, by vibrating, 10 percent less cement can be used, and the same strength maintained. Vibrators work on somewhat the same principle as those used in giving beauty treatments.

The report gives the results of an investigation recently conducted at Arlington, Virginia. Two hundred and seventy slabs of pavement, each 10 ft. wide and 8 ft. long, were constructed and tested. Four different types of vibrating equipment were used, their speeds varying from 3,600 to 4,000 r.p.m.

Slabs of similar composition were placed and finished by standard methods without vibration. Thus, differences in the strengths and physical properties were directly attributable to vibration. In every instance it was found that vibration increased the strength and density and decreased the amount of "honeycomb", or air pockets.

To investigate the effects of vibration further, the quantities of aggregates, cement, and water were varied in slabs finished by the vibration method, and their properties were compared with those of nonvibrated slabs. Slabs 7 and 10 inches thick were placed, and the effects of surface vibration were found to extend entirely through both.

The report, published in the April, 1937, issue of Public Roads, describes ways in which existing specifications for pavement concrete can be modified to utilize vibration to advantage.

Auxiliary Power for Diesel Trains

Multiple engine generator sets synchronize automatically. Load divided between engines by the governors and by special voltage relays

By J. W. Brauns
Transportation Dept.
General Electric Co.

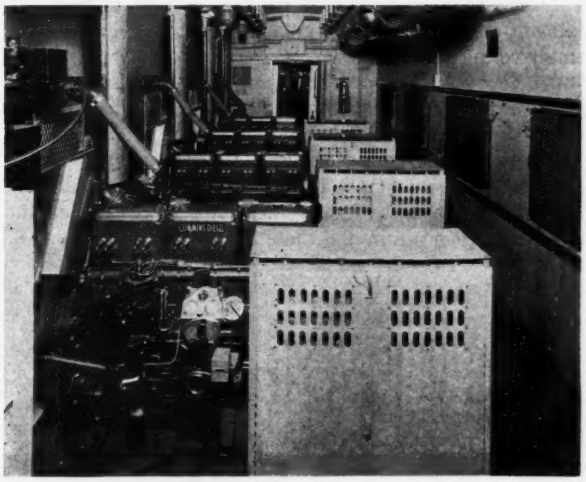


Fig. 1. Four of the auxiliary engine generators on the Denver Zephyr

AUXILIARIES power supply on high-speed streamlined trains must be compact, light weight, flexible, simple, and economical in order to be consistent with the other component parts of the train. To meet all these conditions the Chicago, Burlington & Quincy Railroad chose three 50-kw. engine-alternator sets for its Twin Zephyrs and four 50-kw. sets for the Denver Zephyrs. The engine selected is a 6-cylinder, 1200-r.p.m., Cummins Diesel driving a General Electric 50-kw., 3-ph., 60-cycle alternator having aluminum frame and end shields. The total connected load varies with the seasons and the time of day. The minimum load in the day time in the winter requires only one engine-alternator set, and the maximum load at night in the summer requires two sets on the Twin Zephyrs and three sets on the Denver Zephyrs. One set is thus available as a spare in each train.

To keep the power lines and wiring at a minimum weight, only two 3-ph., 220-v. train lines are run through the train. One line feeds the air conditioning motors; the other feeds the train lights, evaporator fan motors, etc. The load on the train lighting bus consists mainly of the lights and a few small motors which eliminates voltage fluctuation due to motor starting.

On the Denver Zephyrs provision was made in the control so that units 1 and 2 feed the 3-phase air-conditioning train line and units 3 and 4 feed either the air conditioning or the train lighting train line. No combination of engine-alternator set has been set up on this basis before, and no definite information was available as to how these sets could be made to share the loads equally under all operating conditions, or whether automatic synchronizing as outlined below would be practical.

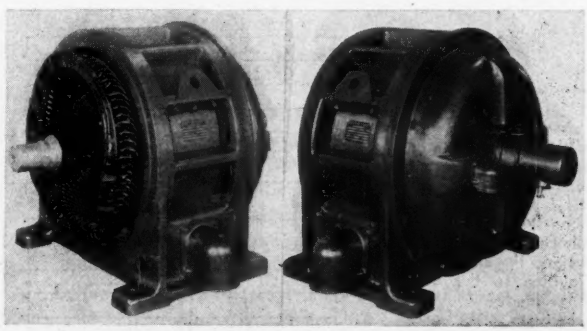


Fig. 2. One of the 50 kw., 1200 r.p.m., 220-v., 3-ph., 60 cycle generators. The centrifugal switch at the right end of the shaft closes the line contactors at approximately synchronous speed

Automatic synchronizing is obtained by simply opening wide the engine throttle. When the alternator set comes up to approximately synchronous speed, a speed switch mounted on the shaft extension of the alternator closes the alternator line contactors. This operation places the alternator across the 220 volt line as a synchronous motor. The closing of an interlock on one of the line contactors applies the field to the alternator. The incoming machine is now in parallel with the other alternator on the line. With proper field current and engine governor settings as determined by the load conditions, each engine alternator set delivers its prorated output.

The division of load among engine-driven a-c generators operating in parallel is dependent upon the power supply to each generator as controlled by the governor of each engine, and is practically independent of excitation. The division of reactive current among generators is a function of the excitation. For generators in parallel, any system of voltage regulation must, therefore, provide for proper division of the reactive current among the machines.

In considering the application of a system of regulation to a number of alternating-current generators operating in parallel, it should be remembered that the change in excitation of any one of the generators does not appreciably affect the bus voltage. The chief effect is to change the reactive current supplied by that particular machine, as the other machines will tend to maintain the voltage level constant. Increasing the excitation will tend to make a machine supply more reactive current, and decreasing the excitation will make it supply less reactive current. To raise the bus voltage, it is necessary to increase the excitation of all the machines.

In order to obtain successful parallel operation of two or more generators with individual voltage control relays on each alternator, the relay must hold the voltage reason-

ably constant, and provide proper division of reactive kilovolt-ampere load among the generators regardless of small voltage changes.

A new voltage control relay on these trains functions to give proper field current and voltage. The proper engine governor and throttle setting produce prorated kilowatt output from each alternator when operating in parallel. Usually meters are provided to indicate directly the kilowatt output of each alternator; but, to keep the equipment to a minimum, these meters were omitted.

Each alternator receives its excitation directly from a storage battery. The battery is changed either from a 1500-watt auxiliary generator mounted on each engine or a 5-kw. motor-generator set. The performance of these engine alternator sets has met all requirements of the train in providing auxiliary power supply, and at the same time the minimum weight and space limitations have been adhered to. Other important features of this equipment are its simplicity, flexibility and operating economy.

Gas Engines for Power Generation

Belting a gas engine to a motor cuts purchased power costs and gives a flexible, simple and inexpensive arrangement for commercial and industrial use*.

By Ralph S. Wenner
The Ohio Fuel Gas Co., Toledo, O.

PRACTICAL AND INGENIOUS, a plan susceptible to wide industrial application in areas where natural gas is available has been in successful experimental operation for some time in Ohio. While its main purpose is to substitute gas engines for central station current, it offers a simple method by which power plant efficiency can be stepped up without materially changing the existing installation.

All that is necessary in an existing installation is to couple a gas engine to the main motor of a plant or machine and drive the load at synchronous speed through the motor shaft with the motor idling but connected to the line. If electric power is needed for auxiliary motors or lighting, the unit may be speeded up and the motor becomes a generator.

An induction motor normally revolves at a speed slightly less than synchronous, the difference depending on the load. The more heavily loaded, the slower its operating speed, although the slip or lag seldom exceeds 10 per cent for small motors or 5 per cent for large motors.

If by the application of power to the motor shaft the motor is caused to rotate at synchronous speed, it is for all practical purposes no longer receiving power from the supply lines, although actually a small amount of power is needed for excitation and regulation.

If the speed is further increased by increasing the engine speed, the motor will become a generator, the electric load that can be carried depending of course on the allowable output of the engine in excess of the mechanical loads. The voltage and frequency of generation are exactly the same as that of the supply line, so that the power generated is suitable for use by any other equipment connected to the line.

Through the use of this plan (on which patents have been applied for and inquiries regarding its use should be addressed to the author) it is possible to take each case, decide how much of the load the engine must take to give a maximum return on the investment and make the application accordingly. Great savings per dollar of investment can be made through the plan for several reasons. The engine can be installed and used approximately twice as large as would be possible if only the mechanical load were considered. The engine may be

*Abstracted from a paper delivered by Ralph S. Wenner at the National Conference on Industrial Gas Sales sponsored jointly by the Industrial Gas Section of the American Gas Association and the Midwest Industrial Gas Sales Council.

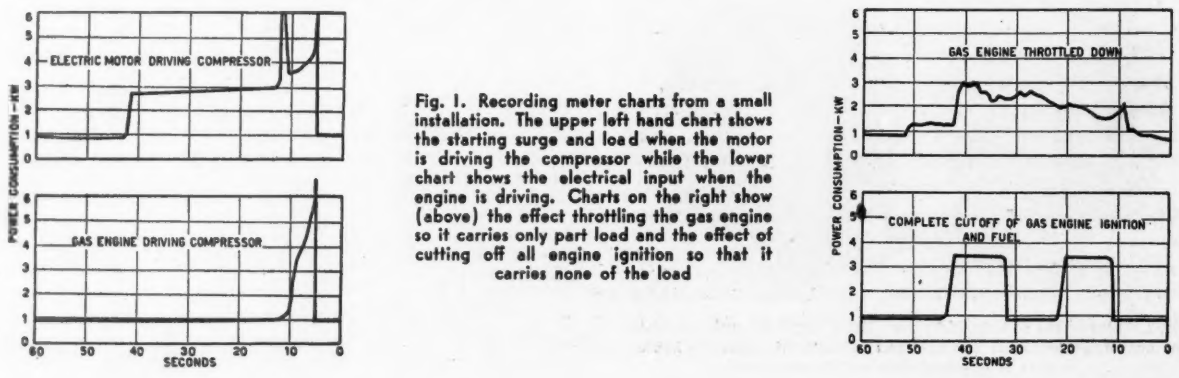

ELECTRIC MOTOR DRIVING COMPRESSOR
GAS ENGINE DRIVING COMPRESSOR
POWER CONSUMPTION - KW
SECONDS
GAS ENGINE THROTTLED DOWN
COMPLETE CUTOFF OF GAS ENGINE IGNITION AND FUEL

Fig. 1. Recording meter charts from a small installation. The upper left hand chart shows the starting surge and load when the motor is driving the compressor while the lower chart shows the electrical input when the engine is driving. Charts on the right show (above) the effect throttling the gas engine so it carries only part load and the effect of cutting off all engine ignition so that it carries none of the load

used large enough to deliver the mechanical load plus an electric load equal to the capacity of the motor as a generator so that the initial cost per horsepower is reduced. This initial investment per horsepower is further reduced because it is not necessary to apply a safety factor for possible overloads as the electrical system cushions this. In most cases only a simple gas engine without starting equipment, clutch or other auxiliaries is needed.

Properly laid out, operation is always at constant full load. Let the mechanical load drop off and the system reaches out and takes a compensating electrical load. Let the mechanical load pick up and an equal electrical load is dropped. The control is inherent in the system itself and involves only very slight change in speed.

A further advantage is that existing equipment is not disturbed, removed or replaced but merely supplemented. The electric motor is still connected to the load and hooked up with central station service. If the gas engine fails, the wheels keep turning just the same. If automatic controls are installed it is not necessary to disturb them. This eliminates the fear, warranted in the customer's mind, of cutting away from utility service. Line shafts, at least not mechanical line shafts, are not introduced although it is perhaps proper to consider that a flexible electrical line shaft has been introduced into the gas engine picture.

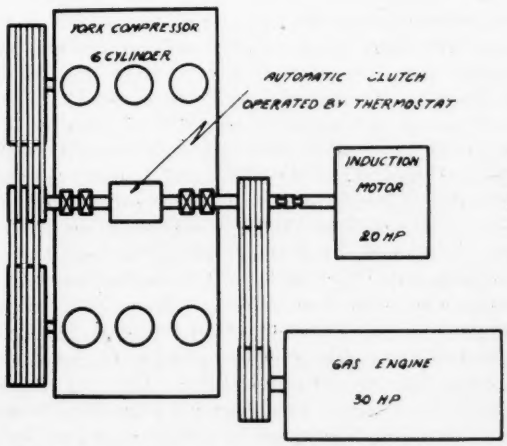


Fig. 2. Layout for an air conditioning installation for year round operation

As the result of all of this, the market possibilities of the gas engine expands tremendously. While the plan has been applied as yet only to a limited number of installations, it has a wide commercial and industrial application. Operating charts for a small installation under different conditions are shown by Fig. 1.

In a grocery store job, the power consumption of 872 kw. for the month ending May 12, 1936, was cut to 83 kw. for the month ending May 13, 1937. The savings after deducting the extra gas bill was $19.80. Assuming equal loads, 789 kw-hr. was replaced by 14,000 cu. ft. of gas, representing a consumption of 17.7 cu. ft. per kw-hr.

A larger installation consisting of a Hercules HXE, 120 hp., 1400 r.p.m. engine driving a blower was made at the Mather Spring Co. plant. Without credit for heat recovered from the exhaust and cooling system the savings, exclusive of maintenance, is estimated $220.55. This is based on the assumption that the engine will use 10 cu. ft. per hp. hr. of gas and operate 400 hr. a month. Operating data to confirm this are not yet available.

Figure 2 shows a proposed air conditioning installation which will permit the use of engine and motor

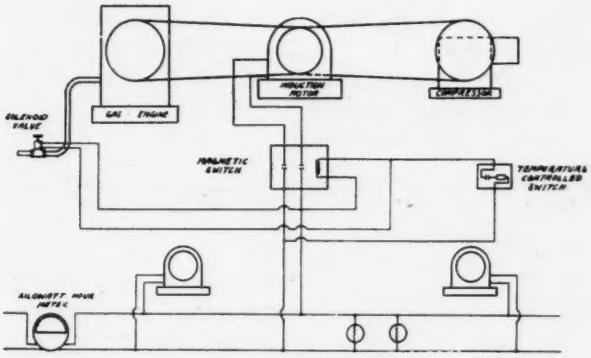


Fig. 3. Diagrammatic arrangement of the wiring and control for the installation shown by Fig. 2

throughout the year, a minimum of 300 hr. per month. The motor will be operated from the engine about 12 hr. a day, 25 days a month. The thermostatic control is shown diagrammatically by Fig. 3.

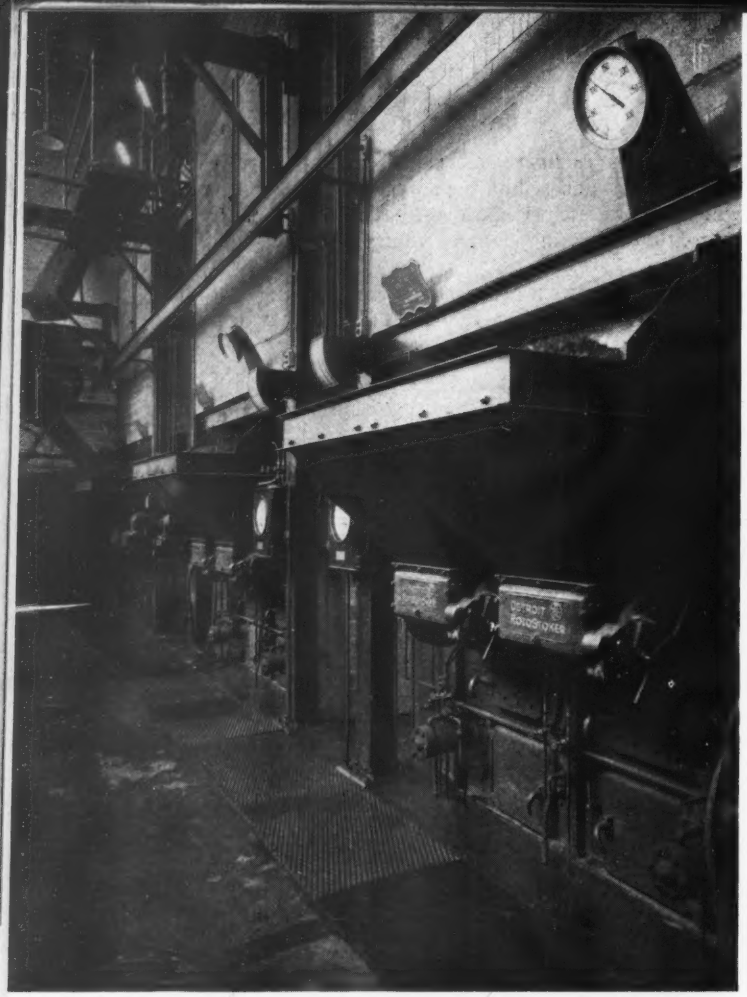
Electric Power Production

PRELIMINARY FIGURES of the production of electricity in the United States during 1937 indicate a total output of 120,996,000,000 kw-hr., an increase of approximately 9 per cent over the record-breaking year 1936. Of this total, approximately 117,742,000,000 kw-hr. were produced for public use and consumption as compared with 108,159,890,000 kw-hr. produced for such use in 1936. The remainder, 3,254,000,000 kw-hr. were produced by electric railroads, electric railways, and other miscellaneous plants.

Production of electricity by the use of water power was about 43,707,000,000 kw-hr., or 12.8 per cent more than in 1936, and amounted to 36 per cent of the total, whereas the average for the 17-year period, 1920 to 1936 was 36.8 per cent of the total.

Preliminary data indicates that the fuel rate for 1937 will be approximately 1.42 lb. per kw-hr. as compared with 1.44 lb. per kw-hr. in 1936. Following the former procedure of the U. S. Geological Survey, the fuel rate was calculated by converting the oil and gas used in the production of electricity into equivalent tons of coal and dividing the total coal used in producing electricity and coal equivalent of the gas and oil used by the corresponding output. This method does not allow for the variation in B.t.u. content of the gas and oil as fired, and includes the output of both steam and internal combustion engines, and is therefore only approximate.

An analysis of all steam plants using coal exclusively for fuel indicates that the coal rate is 1.43 lb. per kw-hr. Since these data include coal used in plants held in reserve and operated intermittently, it is not representative of good practice.



THE FORCED DRAFT SPREADER STOKER

BY
C. C. WILCOX*

Adaptability to various grades of coals, operating results. Effect of moisture in coal. Desirable gas flow. Upkeep of furnace.

Firing aisle of spreader stoker plant

FIRING OF BOILERS of moderate size ranging from about 200 to 700 hp. with bituminous coal from the midwest area has led to the development of the spreader-type stoker, which has shown some rather interesting performance characteristics. While this type of fuel-burning equipment is by no means a panacea for combustion difficulties, it does have some quite desirable features, and definite applications. The outstanding characteristics appear to be extremely low stoker maintenance costs per ton of fuel burned together with the ability to burn a wide range of fuel successfully, and flexibility of adaption to load requirements.

Inasmuch as combustion in this type of stoker partakes of the nature of that of pulverized fuel, it is natural to expect more difficulty from fly ash than with stokers in which the coal is burned in a mass on the grate. More or less controversy has arisen out of this characteristic, but little data seem to be available relative to the quantities of fly ash to be handled.

Another characteristic of this stoker is its adaptability to handling varying grades of coal with varying percentages of moisture. The effect of flame impingement on refractories and the ability to get good distribution of fuel over the entire grate area are also vital factors upon which information from operating experience and research is needed.

Operating Results

As to operation of a spreader stoker installation, Fig. 1, with which the writer is familiar, and which has now been in operation a little over 3 yr. This job consists of three 300-hp. bent-tube three-drum boilers with straight refractory walls, with one row of ventilated carborundum blocks next to the grate line on both sides and rear. The furnace volume is 1056 cu. ft., the furnace width is 7 ft. and the grate area is 65 sq. ft. The stoker is divided into two zones, each with separate ash pit, rotary coal feed, and power dump. Dual drive is effected by a motor on one end of the drive shaft and a steam turbine on the other. Each of the three boiler units has its own fan, and stoker drive but a master combustion control, air-actuated and responsive to steam pressure, controls the position of a lay shaft to which is attached the control levers for coal feed, vortex fan damper and uptake damper.

Fans are turbine driven and were originally controlled by speed regulating valves in the steam lines. This arrangement gave disproportionate functioning at certain parts of the range, hence the vortex damper was substituted for the throttle control, which seems to have solved that part of the problem.

Sufficient length of time has elapsed to afford a fair picture of the behavior of various coals on this type of stoker and, in this regard, we have found it feasible to burn almost any grade of coal available, although of course with some change in fuel cost as would be expected. Indiana fifth vein coal has shown the lowest fuel cost, although not the lowest total cost, including the incidental expense of maintenance and attendance. At present the most favorable over all cost is obtained with Southern Illinois coal. The boiler meters are set for 11 per cent CO_2 and the ash pit blast pressure varies from 0.2 to 5 in., while the depth of fuel bed varies from

*President Wilcox Engineering Corporation.

2 in. immediately after dumping to 6 in. just before dumping. Approximately 0.05 in. draft is held in the furnace. The normal load is only about 125 per cent of rating, although 160 per cent can be carried continuously.

Combustion Problems

Coal having a high moisture content say 12 to 15 per cent gives some trouble in the way of proper distribution, especially if a high per cent of fines (35 per cent) be present. The coal then has a tendency to take a shorter average trajectory, with resulting increase in the thickness of the fuel bed near the front; this, however, has not been particularly annoying and has been overcome by avoiding the ¾-in. screenings and using 1¼-in. grade.

Combustion naturally resembles that of pulverized coal firing, especially with the higher per cent of fines in the fuel. In this case, tube slagging is more noticeable and the temperature of gases entering the tube bank is higher with resultant damage to No. 1 soot blower element. While the damage has not been excessive, it has been noticeable and has apparently been eliminated by the use of a Dialloy element in that location. With a coal high in fines, therefore, we find the fuel bed on the grate thinner and the point of highest furnace temperature shifted upward toward the tube bank.

As corollary to the condition just described is an increase in combustible flue dust carried through the passes. During the months of October and November 1936, 1090 t. of Southern Indiana coal were burned (Buckskin 1¼-in. screenings) during which period 7000 lb. of flue dust was removed from the dust hopper under the mud drum. This represents a loss of less than ⅓ of 1 per cent of the coal or about $4 per month. This dust is manually drawn from the hopper into a 50-gal. drum and wheeled to the ash dump, about one drum per day being handled in this manner. The value of this dust as a fuel (although it contains 85 per cent carbon) is so low and the present labor of removing it so low that no equipment has been installed to take care of it, although provision was made to deliver this dust by steam jet conveyor from hopper directly through the bridge wall to the furnace in case it should be desired.

During December, 1936, we burned 660 t. of Buckskin 1¼ by ¾-in. coal and removed 1800 lb. of flue dust or about 1/7 of 1 per cent of the coal fired, indicating that, the less the fines in the coal, the larger is the per cent of coal burned on the grate and the smaller the per cent burned in suspension and carried over. In January, 732 t. were burned which consisted of a considerable part of so-called "pickings" high in fines when 4300 lb. of dust were removed. In February and March, 1362 t. of Southern Illinois 1½-in. to 0 screenings were burned and 15,200 lb. of dust was removed, or a little over ½ of 1 per cent of coal burned. This represents a loss of about $12 a month during the winter months, which would probably justify the use of reclaiming equipment.

Gas Travel

Observation has been made by engineers that, with this type of stoker, it is desirable to have the gas travel parallel to the grate surface in order to obtain the best results. Our observations verify this statement. When first installed, it was impossible, when burning Indiana coal, to get high CO_2 on the job described without smoke, and a study of conditions existing in the furnace revealed that the large number of comparatively lazy pencil-like flames rising from the fuel were not at any time sufficiently agitated or broken up to give the necessary turbulence and mixing for good combustion. To overcome this, two steam-driven air jets were installed near the front corners of each furnace, directed diagonally backward toward the bridge wall, so arranged as to pull some air in from the outside and to combine this with a larger amount of hot, recirculated furnace gases. This stream of air and gas, intersecting the natural path of the flame rising from the grate, served to effect complete combustion. Virtually the same effect is being obtained in the newer stokers by high velocity air admitted at the furnace front directly from the air duct, and in either case turbulence is effected by a cross

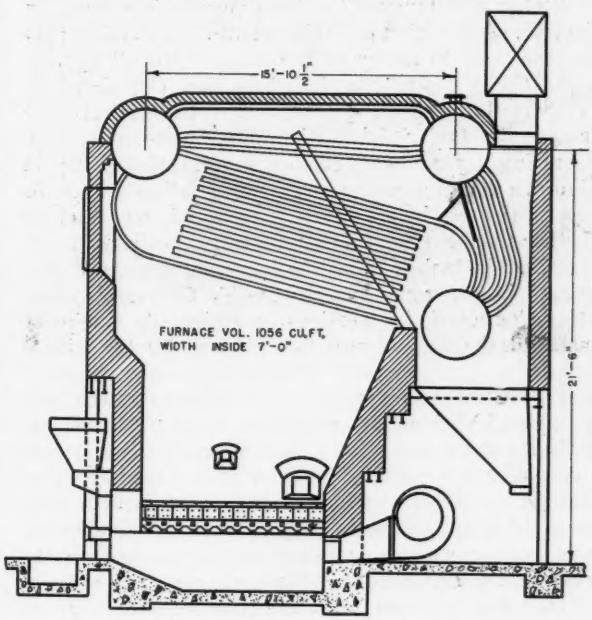


Fig. 1. Cross section of boiler setting for spread stoker

current of gases intersecting the path of flame. This explains the peculiar adaptability of this type of firing to the h.r.t. boiler.

Refractory Upkeep

Air jets referred to first above, however, are not without their drawbacks because, if directed towards a hot wall, a build up of adherent ash will result. With low-fusion-ash coal this occurs in the plant described and it is necessary occasionally to slice this off by access through the rear door. While this procedure is not particularly annoying, it would be eliminated in a furnace having a sufficiently high Psi factor or cold fraction to reduce its temperature below fusion temperature of ash at that point. The present normal heat release approximates 25,000 B.t.u. per cu. ft. per hr. and has repeatedly reached 35,000 for periods of 2 to 4 hr. The projected cold area in the furnace envelope is 105 sq. ft. There is 114 sq. ft. of refractory in each side wall, 86 sq. ft. in the bridge wall and 91 sq. ft. in the front wall, giving a cold fraction of 0.273.

Refractory maintenance has been confined to the lower 3 ft. of the side walls (particularly towards the rear) and the lower part of the bridge wall. Plastic refractory has been used for current repair, but now after 3 yr. of operation this part of wall is being relaid and, due to necessity of removing adherent ash from the lower part of the bridge wall, the carborundum blocks in the bridge wall have suffered mechanical injury and need replacing. As stated, a single row of carborundum blocks were laid at the grate line. This has been quite effective in resisting slag action and erosion by hot gases and the performance of the wall would apparently have been improved had this construction been carried up to the 3-ft. level. With the exception of the mechanical injury noted, the carborundum is still in good condition.

Stoker Operation

Stoker maintenance has been very satisfactory. In the 3 yr. of operation no replacement of any stoker part has been due to action of the fire and, to all appearances, the grates have an indefinite life. Certain rotating parts have been replaced, due to mechanical wear caused by faulty lubrication, and cast-iron dump-operating levers have broken several times due to vigorous dumping action caused by needlessly high air pressure; these levers are now made of steel, and no further trouble from this source seems probable.

The thin fuel bed and the large percentage of fuel burned in suspension are responsible for certain operating characteristics worthy of mention. As originally installed, the stokers were motor driven for the sake of simplicity, but occasional interruption to power supply and the consequent stopping of coal feed produced such a sudden and complete reduction in heat release that difficulty was experienced in sustaining the load at such times. For this reason, dual drive of coal feed by steam turbine was added and apparently constitutes a complete solution. The possibility of quickly reducing the heat release with a minimum weight of fuel on the grate, is a valuable characteristic where sudden changes of load are to be met, and the time required for this change can be further reduced by increasing the furnace cold fraction. In certain cases the large amount of heat stored in refractory furnace walls and partially burned fuel on the grate makes it difficult to avoid popping of the safety valve, even though the steaming rate be reduced as much as possible by increasing the feedwater. With power dump and adequate ash quenching facilities, the heat release from fuel can be reduced to zero in a matter of seconds if desired, and an increase in coal feed finds instant response in increased heat release. This extreme sensitiveness permits considerable flexibility in operation and demands some care in the design of furnace to make the best selection of heat-absorbing surfaces and get the most out of this type of firing.

Uses of welding in air conditioning equipment are summarized by the Journal of American Welding Society. Frames, housings and supports for air filters; drip pans and banks for spray systems; piping and fin coils for air heating and cooling; piping for steam and water systems; blowers, casings and air ducts.

Welded Building Construction

IN THE ERECTION of the new 200,000-sq. ft. factory addition of Lincoln Electric Co. at Cleveland, it was natural that electric arc welding should be used. Two advantages have been utilized by The Austin Co., who designed and erected it. First, welded rigid frame saw tooth design with "tree-form" columns, recently developed by that company, in which the components, cut and rolled to proper size and shape, are placed in jigs and welded into one integral piece, then welded to standard H beams to provide main and stud columns.

Photo Courtesy of The Austin Co.

Erection of Welded-Frame Building by The Austin Co. for Lincoln Electric Co.

Second, design of the structure for welded construction so that much of the work could be fabricated at the shop before erection, leaving a minimum to be done on the job. In the present instance, 25,000 ft. of welding was shop work and 4600 ft. erection on the job. This contributed to speed of erection and low cost, 93 t. of steel being set up in one 8-hr. day and 1314 t. between July 7 and Aug. 2.

In the construction, Lincoln Shield-Arc welding generators were used and 5½ t. of Fleetweld coated arc-welding electrodes. Cost of construction is stated as substantially lower per ton of steel than for previous welded buildings.

Utilization of Natural Gas in Power Boilers

Natural gas makes an ideal fuel and by paying careful attention to a few fundamental principles boilers can be converted to gas firing and efficiencies of 75 to 80 per cent obtain

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USE OF NATURAL GAS as a fuel for the larger boilers is becoming greater each year and many interesting discoveries have been made as to the action of gas as a fuel. There has been and still is considerable discussion as to the proper amount of combustion space required for the combustion of natural gas.

Due to the many different furnace conditions found, there cannot be fixed a hard bound rule as to the number of cubic feet of combustion space per developed horsepower. Primarily the amount of combustion space is controlled by the temperature at which it is desired to operate the furnace. This temperature, in turn, is dependent upon the amount of black surface exposed to the radiant heat, the refractories and the distance this black surface is from the radiant surface.

In one installation, a 100,000 lb. per hr. boiler had a maximum heat release of 13,400 B.t.u. per cu. ft., or, approximately 3½ cu. ft. per developed horsepower. The temperature of this furnace was 2840 deg. F. at maximum load for the reason that the furnace was built for powdered coal and when gas burners were installed they were placed near the bottom of the furnace, approximately 25 ft. from the black surface, which was small. This high furnace temperature caused undue maintenance with the result that changes had to be made. It was found that it would be cheaper to install a water wall on the rear wall opposite the burners and duct work. When this wall was installed the furnace temperature was lowered to a maximum of 2280 deg. F.

*Vice-chairman, Steam Generation Committee of the American Gas Association before which this paper was presented.

A case in the other extreme was of a low set Heine type boiler where the release at maximum rating was 60,000 B.t.u. per cu. ft., or, approximately ¾ cu. ft. of combustion space per developed horsepower. Yet the temperature did not exceed 2545 deg. F. at maximum rating because the tubes were close to the floor, approximately 8 ft., and the furnace width was greater than usual.

Proper Volume

These two instances illustrate my theory that combustion space is governed by proximity and quantity of black surface exposed to the radiant heat of the furnace. A safe rule to follow, on the average boiler of either the Heine and Stirling type with the standard settings, is to try to develop not more than 7 b.hp. per sq. ft. of exposed black surface, and, use a combustion space of not less than 1½ nor more than 2 cu. ft. per developed horsepower with the exposed black surface approximately 12 ft. from the radiant furnace floor.

To obtain the above conditions on a straight tube boiler it is necessary to remove the bridgewall, use the entire furnace length, place burners in the rear or low end as shown by Fig. 1 and change baffling, which will be described later.

On the bent tube boiler, burners should always be placed in the rear, under the mud drum, as shown by Fig. 2, so that the full amount of combustion space can be utilized. The flame travel should be directed toward the front wall and up the tube bank so that there will be no concentration of heat on the bend at the lower

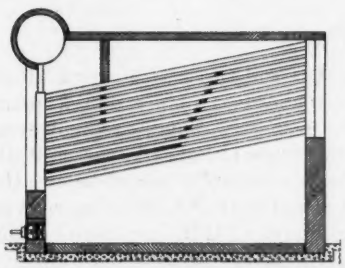


Fig. 1. The best arrangement of burner and baffles for converting a straight tube boiler to natural gas firing

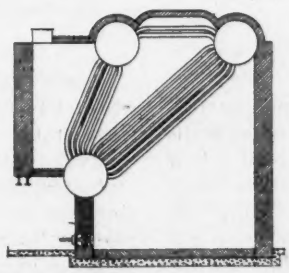


Fig. 2. A bent tube boiler should be fired from the rear to properly utilize the combustion space and avoid gas impingement on the lower ends of the tubes

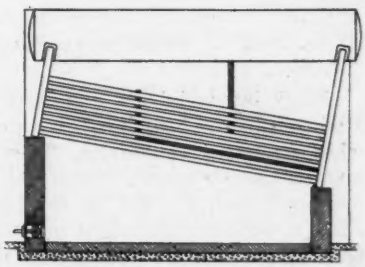


Fig. 3. A low set straight tube boiler may be fired from the high end if the expense of a change over is not justified. The baffling should be changed as shown with the horizontal baffle above the second row of tubes

end of the tubes where they enter the drum as there would be if the burners were installed in the front wall. If the expense of changing baffling, etc., is not warranted and if the rating is 100 per cent or less then burners may be placed in front walls in either of the above cases.

With a boiler using powdered coal, where a gas insert cannot be used and separate gas burners must be installed, these should be placed above the coal burner so that the heat will be close to the black surface. Where the powdered coal burner is removed entirely and gas is used with oil as standby, a false floor should be built, giving approximately 1½ to 2 cu. ft. of combustion space per developed horsepower with the burners close enough to the floor to keep it in a radiant condition.

Baffling

When a straight tube boiler is converted to gas and fired from the rear or low end with the bridge wall removed, a horizontal baffle must be run from the lower end of the vertical baffle (which has been cut off to the second row of tubes) to the rear or low end of the boiler on top of the second row of tubes as shown in Figs. 1 and 2. In the case of a bent tube boiler, the baffling does not have to be changed as to position unless the first baffle is closer than the second row of tubes. Then it must be moved back.

There are still in service a number of straight tube boilers that are horizontally baffled with the first baffle covering the first row of tubes with an opening to the first pass at the rear or low end of the boiler. To get the highest efficiency this baffling should be changed to a combination vertical and horizontal baffle. If the difference in efficiency, approximately 2 per cent, does not warrant this change, then the horizontal baffle on the first row of tubes must be raised to at least the second row and the burners installed in the front or high end of the boiler.

Many a gas conversion installation has failed due to leaky baffles which allowed the by-passing of the products of combustion to reduce efficiency due to high stack temperature. Before placing the boiler into service, carefully check for leaks and repair each one, no matter how small. Where there has been considerable slagging of baffles from coal, they will be tight at first due to the slag, but in a short time this slag will crack or melt off, leaving serious leaks. To check for leaks, the draft in each pass should be tested at least once each week for approximately four weeks after gas has been used.

Furnace Insulation

Many industrial gas engineers do not pay enough attention to the heat losses through the furnace walls when making a conversion. They do not realize how many B.t.u. per square foot is lost through the average fire brick wall of 13½ in. thickness. By taking this 13½ in. wall and placing it in first class condition and backing it up with 4½ in. of insulating brick, 165 B.t.u. per sq. ft. of surface can be saved with furnace temperature at an average of 2200 deg. F.

There is considerable question among engineers of the relative value of an air cooled over a solid wall. In the case of natural draft insufficient to pull all air for combustion through the air cooled walls, a well insulated solid wall is the most economical. Furthermore, where there is enough draft to pull all air through the walls, it is usually so great that the velocity of the products of combustion are such that they pass over the black surfaces so fast that they do not give off as many B.t.u.'s as they should.

My opinion is that unless forced draft is used, (where you can pull air through hollow walls and discharge it through burners into furnace close to a negative pressure) the well insulated solid wall is the best. The water wall type of construction is being used to a great extent today, even in the smaller boilers, and it is, in my opinion, the best for a new boiler and furnace.

Draft

Many times burner equipment with high draft loss across burner is installed because the high draft is available and because it is cheaper than larger equipment. Where natural or induced draft is used, this is wrong because when the furnace draft exceeds 0.15 in. w.c. the efficiency begins to drop off quickly due to the increased velocity of gases over the heating surface and a resulting high stack temperature.

High draft also affects the leakage of air through furnace walls, increasing the excess air and diluting or cooling the products of combustion. If it is at all possible, keep the furnace draft within 0.15, and in no case exceed, 0.25 in w.c. in the furnace. Larger equipment is cheaper than poor efficiency in the long run.

Efficiencies

There is a wide deviation in views of engineers as to efficiencies that may be obtained with natural gas as a fuel. With proper burner equipment properly installed and controlled, an average of 75 per cent overall efficiency can be obtained and maintained in both the straight tube and bent boilers without economizers and superheaters. When a superheater or economizer only is used, this can be stepped up to an average of 77 per cent. When both superheater and economizer are used, it is possible to average as much as 80 per cent. The above figures are actual results of tests obtained from many installations.

This can not be done by just putting burners in a boiler. A study should be made of the baffling, furnace shape and insulation, etc., and the necessary changes made. A large boiler consumes a large amount of gas and will justify a considerable expense to get the proper installation.

Gas Burner Equipment

There are many makes and types of burners, all of which have their good and bad points and a place where they will work properly. There are, however, really only three distinct types of burners; the multiple jet atmospheric type for pressure of 2 lb. and below; the ring type and centrally fired type of high pressure type register burner for pressures of 2 lb. and above. Any of these burners, regardless of make, when properly applied will give the utmost in efficiencies. In firing the large power boilers, the high pressure burner should always be used wherever possible as higher ratings, shorter fire and less cost of equipment may be obtained.

Part XXIII. Further consideration of commercial tube types with particular reference to pin arrangement and classification. Meaning of plate resistance, mutual conductance and amplification factor

ELECTRON TUBES— Principles and Applications

By A. W. KRAMER

AS WAS POINTED out in the preceding article, the great number of tube types listed in the tables need cause no confusion if we remember that all tubes can be grouped into a comparatively small number of classifications either according to function or cathode-filament voltage. One should make it a point to become reasonably familiar with the tables in order to derive the greatest possible use from them; they really contain a great deal of useful information.

The tables give the maximum ratings for the various types of tubes listed as well as much other pertinent data involving their application. In the interest of long tube life, filament or heater voltages should always be maintained as nearly as possible at the rating given (variations not more than 5 per cent either above or below rated voltage) and the maximum plate-supply voltage indicated should not be exceeded. Furthermore, it is important that a tube be operated with the proper negative bias, as indicated by the tables, applied to the grid, since failure to do so will not only cause failure of the tube but faulty operation. The amount of grid bias, as pointed out briefly in the preceding article in the case of amplifiers is largely the determining factor as to the class of amplifier operation obtained.

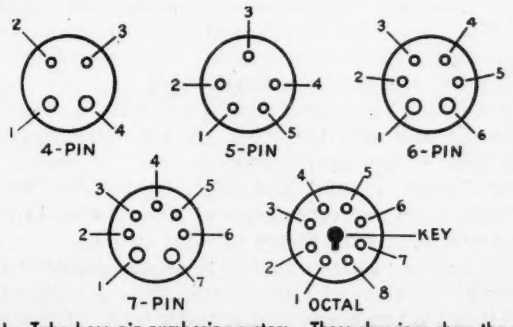


Fig. 1. Tube base pin numbering system. These drawings show the pins looking at the bottom of a tube base or socket. Pins are numbered in a clockwise direction starting with the left hand cathode pin as No. 1 with glass tubes but with the shield pin as No. 1 with the metal tubes. The metal tubes are characterized by the octal base. On the 4, 6 and 7 pin bases the cathode pins are heavier than the others

For the correct use of tubes in circuits it is of course necessary to know how the internal elements are connected to the pins and how the pins are arranged. Tube bases have from four to eight pins for element connections. In all except the five and eight prong types, the two cathode pins are heavier than the others, making them readily distinguishable and providing an arrangement which permits the insertion of the tube in the socket in only one position. The pins of all tubes except those of the 8-pin or octal base (which is the base developed first for the recent metal tubes) are numbered in accordance with the system shown in Fig. 1. Looking at the bottom of the base or the bottom of the socket, the left hand cathode pin in No. 1, and the others are numbered consecutively in a clockwise direction, ending with the right hand cathode or heater pin.

The metal tubes all have 8-pin bases but only those pins needed for connections are actually molded into the base, consequently a single type of socket will accommodate any tube of the metal series. The development of metal tubes with the octal base system of pin arrangement created a demand for this same type of base arrangement for glass tubes; hence, practically all of the now-used glass tubes can be obtained with octal bases. Such tubes have the suffix "G" attached to the type number. In some cases these tubes duplicate in characteristics types in the metal series; when this is so, the tube carries the same number as the corresponding metal tube but with the suffix "G" added. Thus, the glass equivalent of the 6H6 metal tube is known as the 6H6. Other "G" tubes duplicate existing types of glass tubes with old type bases and in still others the tube is a new tube with an octal base.

Many of the tube types found in the tube tables are old tubes which are rarely used today since they have been superseded by better tubes, but this data on these older tubes is necessary for replacement purposes.

In indicating which element is connected to the various pins, it is customary to use the letters, F, F or H, H, for filament or heater, C or K for cathode, P for plate, etc. In multi-grid tubes the grids are numbered accord-

ing to the position they occupy, the grid nearest the cathode being No. 1, the next, No. 2, and so on. Some tubes, as may have been noted, are provided with a cap connection on top especially when it is desired that the element connected to the cap have very low capacity to other tube elements.

The standard method of indicating tube arrangement is shown in Figs. 2 and 3. These diagrams represent views of the bottom of the bases or sockets. The disposition of the actual tube elements is shown in the inner circle while the pin arrangement is shown between the inside and the outside circle. The pins are both numbered and lettered. The letters, as explained, denote the elements, F for filament; H, heater; C, cathode; G, grid; S, screen; Sup, suppressor; P, plate; G1, G2, G3, etc., denote the grids numbered in order from the cathode outward; G_1, G_2, P_1, P_2, etc., denote the grids and plates of multi-purpose or twin element tubes; elements having the same subscripts belong together. A top cap on the tube is shown by an external unnumbered connection.

The letters below each tube diagram refer to corresponding letters in the tube tables, so that the diagram of connections for any tube listed in the tables is easily available. A portion of a tube table is shown in Fig. 4.

Until recently tubes were given arbitrary numbers as they were placed on the market. For the past few

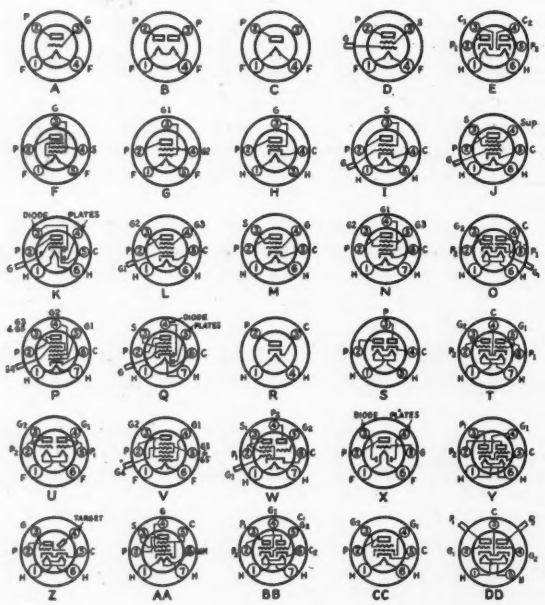


Fig. 2. Base diagrams of glass tubes. These views are of the bottom of the bases or sockets. F, filament; H, heater; C, cathode; G, grid; S, screen; Sup, suppressor; P, plate. G1, G2, etc., denote grids numbered in order from the cathode outward; G_1, G_2, P_1, P_2, etc., denote grids and plates of multi-purpose or twin tubes having separate sets of elements. Elements having the same subscripts belong together. A top cap on the tube is shown by an external unnumbered connection

years, however, a numbering system has been in effect, which, to some extent indicates the nature of the tube. These designations involve a number, a letter, and a final number. An example of this method of numbering is the 2A5. These numbers are formed according to the following simple rules. The first numeral indicates the filament or heater voltage in steps of 1 v. For instance, 1 is used for voltages below 2.1; 2 is used for voltages between 2.1 and 2.9, inclusive; 3 for voltages between 3.0 and 3.9, inclusive. The digit 1, rather than the digit 2, is used for the 2.0 v. types in order to separate the 2.0 and 2.5 v. tubes.

The letter is used to distinguish the tube type and is assigned, starting with A, in alphabetical sequence. In the case of rectifiers, however, the assignment is made starting with Z, in reverse sequence. The final number indicates the number of useful elements brought out to terminals. Thus the 2A5 has five such elements, a heater, a cathode, two grids and a plate. By this method then,

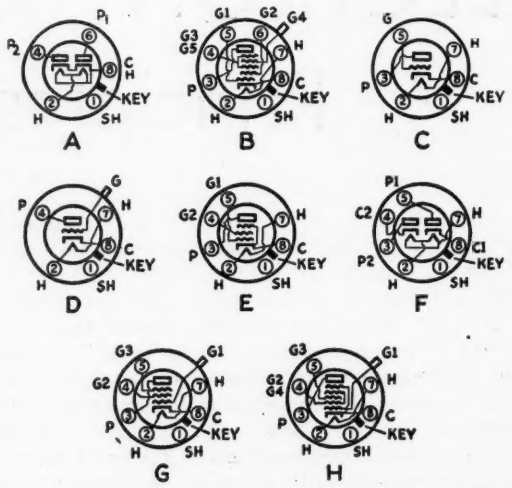


Fig. 3. Base diagrams of metal tubes. Letters and numbers have the same significance as in Fig. 2 but with the addition of DP, diode plates, and SH for shield. The shield is the metal envelope of the tube, in all cases connected to pin No. 1

the designation 2A5 means a tube with a 2.5 v. filament voltage with 5 elements brought out to connection and the first 5 element tube of the 2.5 v. series.

The tubes referred to above are those manufactured for general experimental and radio use. For industrial uses special lines of tubes have been developed using different designations and which are said to be more carefully made than the ordinary radio tube, which is not licensed for commercial industrial use. Each manufacturer uses his own method of designating such tubes. Thus, the General Electric Co. will have series of tubes such as PT-841, PT-842, FP-52, KC-1, the prefix usually referring to the type of tube. Westinghouse, on the other hand, will have tubes such as RJ-550, WL-196, KV-676. These industrial type tubes in many cases duplicate the characteristics of the experimental or radio type tubes, but they are usually sold at a very much higher price. The socket arrangements also are usually quite different and the tubes are not interchangeable with those of the experimental type for this reason. Industrial tubes, it must be understood, however, are no different from any other types of tubes, either in principle or size, and the theory of tubes as it has been presented in these articles applies to all. A gas filled tube going by the name of Phanatron is still a gas filled tube and if it has two elements it is still a diode. Tubes have been classified by various names such as Kenotrons, Phanatrons, Thyratrons, etc., but this system is not in general use—it was devised by the General Electric Co. and used only by them.

This lack of standardization in designating and designing industrial tubes is to be regretted and it arises from no scientific reason; it is primarily the result of commercial and legal factors.

While this more or less informal discussion of the commercial forms of tubes is somewhat unrelated to the general tone of these articles, it is nevertheless of importance in the practical use of tubes since it may relieve some of the confusion which must inevitably result from the beginner's first encounter with commercial tube data.

In the application of tubes, the tube data tables and the graphic characteristics are of the utmost importance since it is by means of this data that the performance of any tube can be predetermined. It is essential, therefore, that one should become at least reasonably familiar with the different types of tubes on the market and with the meaning of the data presented in the tables.

In considering the characteristics of electron tubes, it may be pointed out that these fall into two classes, the first known as the static characteristics and the second the dynamic characteristics. The static characteristics are values of certain qualities of the tube obtained with different d.c. potentials applied to the tube electrodes, while dynamic characteristics are the values obtained with an a.c. voltage on the control grid under various conditions of d.c. potentials on the electrodes. The dynamic characteristics are, therefore, indicative of the performance capabilities of a tube under actual working conditions. Dynamic characteristics include amplification factor, plate resistance and mutual conductance.

The amplification factor of a tube or the μ is the ratio of the change in plate voltage to a change in control-electrode voltage in the opposite direction under the condition that the plate current remains unchanged. For example, if the plate voltage is changed 30 v. and the grid voltage is changed 5 v. (in opposite polarity) in order to hold the plate current at a constant value, the amplification factor is 30 divided by 5, i. e., 6. In other words, a small voltage variation in the grid circuit of a tube has the same effect on the plate current as a large plate voltage change—the latter equal to the product of the grid voltage change and the amplification factor.

The plate resistance of a tube is the resistance of the path between cathode and plate to the flow of alternating current. It is the ratio of a small change in plate voltage to the corresponding change in plate current, and is expressed in ohms. Thus if a change of 0.001 amp. is produced by a plate voltage variation of 20 v. the plate resistance is 20 divided by 0.001 or 20,000 ohms.

The mutual conductance, or as it is sometimes known, the grid-plate transconductance, is a factor which combines in one term the amplification factor and the plate resistance; it is the ratio of the first to the second. Mutual conductance may be more strictly defined as the ratio of a small change in plate current to the small change in the control-grid voltage producing it, under the condition that all other voltages remain unchanged.

Thus, if a grid voltage change of 10 v. causes a plate current change of 0.01 ampere (10 ma.) with all other voltages constant, the mutual conductance is 0.01 divided by 10 or 0.001 mho. Since the plate current changes involved are usually very small, the mutual conductance is usually expressed in millionths of a mho, or micromhos. Therefore, in the example, 0.001 mho times a million equal 1000 micromhos. The mutual conductance characteristic of a tube is a very useful one when comparing a tube's performance capabilities with those of the same type in similar applications.

Type	Name	Base [4]	Socket Connections [1]	Cathode	Fil. or Heater Volts	Fil. or Heater Amps	Use	Plate Supply Volts	Grid Bias	Screen Volts	Screen Current Ma.	Plate Current Ma.	Plate Resistance, Ohms	Mutual Conductance Micromhos	Amp. Factor	Load Resistance Ohms	Power Output Watts	Type
6A4[3]	Pentode Power Amplifier	5-pin M.	F	Fil.	6.3	0.3	Class-A Amplifier	100 180	−6.5 −12.0	100 180	1.6 3.9	9.0 22.0	83250 45500	1200 2200	100 100	11000 8000	0.31 1.40	6A4
6A6	Twin Triode Amplifier	7-pin M.	T	Htr.	6.3	0.8	Class-B Amplifier	250 300	0 0	—	—	Power output is for one tube at stated load, plate-to-plate				8000 10000	8.0 10.0	6A6
6A7	Pentagrid Converter	7-pin S.	P	Htr.	6.3	0.3	Converter	250	−3.0 min.	100	2.2	3.5	360000	Anode grid (No. 2) 200 volts max., 4.0 ma. Grid leak, 50000 ohms.				6A7
6B5	Special Power Amplifier	6-pin M.	Y	Htr.	6.3	0.8	Class-A Amplifier	300	0		6[5]	.45	24100	2400	58	7000	4.0	6B5
							Push-Pull Amplifier	400	−13		4.5[5]	40	—	—	—	10000	20	
6B7	Duplex-Diode Pentode	7-pin S.	Q	Htr.	6.3	0.3	Pentode R.F. Amplifier	250	−3.0	125	2.3	9.0	650000	1125	730	—	—	6B7
							Pentode A.F. Amplifier	250	−4.5	50	—	0.65	—	—	—	—	—	
6C6	Triple-Grid Detector Amplifier	6-pin S.	J	Htr.	6.3	0.3	Screen-Grid R.F. Amplifier	250	−3.0	100	0.5	2.0	exceeds 1.5 meg.	1225	exceeds 1500	—	—	6C6
							Bias Detector	250	−1.95	50	Cathode current 0.65 ma.	—	Plate coupling resistor 250000 ohms					
6D6	Triple-Grid Variable-μ Amplifier	6-pin S.	J	Htr.	6.3	0.3	Screen-Grid R.F. Amplifier	250	−3.0	100	2.0	8.2	800000	1600	1280	—	—	6D6
							Mixer	250	−10.0	100	—	—	—	Oscillator peak volts = 7.0				
6E5	Electron Ray Tube	6-pin S.	Z	Htr.	6.3	0.3	Indicator Tube	200 250	0 0	— —	— —	0.2 0.25	Target Current 4.0 ma. Target Current 4.5 ma.				— —	6E5
6F7	Triode Pentode	7-pin S.	W	Htr.	6.3	0.3	Triode Unit Amplifier	100	−3.0	—	—	3.5	17800	450	8	—	—	6F7
							Pentode Unit Amplifier	250	−3.0	100	1.5	6.5	850000	1100	900	—	—	
							Pentode Unit Mixer	250	−10.0	100	0.6	2.8	Oscillator peak volts = 7.0				—	
36	Tetrode R.F. Amplifier	5-pin S.	I	Htr.	6.3	0.3	Screen-Grid R.F. Amplifier	100 180 250	−1.5 −3.0 −3.0	55 90 90	— — 1.7	1.8 3.1 3.2	550000 500000 550000	850 1050 1080	470 525 595	—	—	36
							Bias Detector	100 250	−5.0 −8.0	55 90	— —	Plate Current to be adjusted to 0.1 ma. with no signal					— —	
37	Triode Detector Amplifier	5-pin S.	H	Htr.	6.3	0.3	Class-A Amplifier	90 180 250	−6.0 −13.5 −18.0	—	—	2.5 4.3 7.5	11500 10200 8400	800 900 1100	9.2 9.2 9.2	—	—	37
							Bias Detector	90 250	−10.0 −28.0	—	—	Plate Current to be adjusted to 0.2 ma. with no signal					—	

Fig. 4. A portion of a typical tube table

Operating Experiences with the THYRATRON MOTOR at the LOGAN PLANT

By A. H. BEILER
American Gas and Electric Co.

Ever since the first announcement of the development of the Thyratron Motor described in the April 1935 issue of Power Plant Engineering there has been much interest in a practical application of this motor. A motor of this type was installed at the Logan Power station of the Appalachian Electric Power Co. in May 1936, but until the presentation of this paper by A. H. Beiler before the winter meeting of the American Institute of Electrical Engineers, its operating performance had not been made public. This abstract of Mr. Beilers paper gives a complete account of the operating experience with this motor at the Logan Plant.

THE QUEST for a simple variable speed a.c. motor has been long and, heretofore, not particularly successful. Consequently, ever since the thyratron motor was mentioned during the early years of the present decade, it has aroused a great deal of interest among engineers, both because of its operating principles and because it appears to offer the possibility of a really effective and economical variable-speed alternating current drive. It has been of particular interest to central station engineers.

The advantages offered by the thyratron motor when first announced appeared sufficiently attractive so that the American Gas and Electric Co. urged the completion of developments on this motor and was in close contact with the manufacturer as the work progressed. In a development of this kind, it is particularly essential that the operating requirements are clearly brought to the attention of the designers. Their concentration on the theoretical aspects of the problem sometimes leads them to overlook homely but nevertheless important details.

Rated at 400 hp., 2300 v., 3 phase, 60 cycles, the thyratron motor installed at the Logan plant was designed to drive an induced draft fan having a speed range from 625 to 350 r.p.m. It closely resembles a standard synchronous motor with a rotating field, except that it has two independent star-connected stator windings installed in the same slots. Unlike a synchronous motor, however, the field terminals after being brought out through slip rings, connect to the neutral points of the star windings. As shown in Fig. 2 the six remaining power leads connect in a special arrangement to a series of 18 type FG-118 thyratron tubes, each having a continuous rating of 12.5 amperes and a maximum rating of 75 amp.

Accessory equipment includes a three-phase current limiting reactor, a thyratron-tube cubicle, and a speed-control panel. Each tube is mounted in an individual removable cell so as to facilitate replacement during operation. Tube cooling ducts and blowers, heater and grid transformers, etc., are all assembled within the cubicle.

The speed control panel contains a small wound-rotor motor functioning as a phase shifter for the purpose of effecting the desired speed changes.

The 18 thyratron tubes consume about 3½ kw. at full load with another 1½ kw. consumed in the various auxiliary transformers and relay coils in the cubicle. Forced air circulation is used to dissipate the tube losses. For winter operation, the cooling system is operated partly closed and is supplemented by strip heaters. In summer time it operates entirely open and without heaters.

About 800 watts are consumed in excitation losses in the stator of the small wound-rotor motor which acts as a phase shifter for speed control, but since this is mounted on the speed-control panel which is remote from the cubicle, it does not contribute to the heat generated there. The 220 v. auxiliary power totals to about 57 kw-hr. in a 24-hr. day, this load remaining practically constant regardless of the motor load.

A series of 18 glow lamps, excited from small current transformers in the cathode circuits serve for remote indication of tube performance. In addition, a relay energized through a tuned circuit in the motor field circuit rings a bell to indicate abnormal tube firing.

A cathode timing relay is used to insure preheating of the cathodes for approximately 15 minutes before the 2300 v. oil circuit breaker can be closed.

A distributor is mounted on the motor shaft to obtain commutation of energy between thyratron tubes. The distributor segments are connected to the grids through intermediate transformer. Two sets of segments are used, one for normal speed and a supplementary set effective at low speed by utilizing the inherent commutating action of the three phase power supply to obtain

a high starting torque. Transfer between sets is made automatically at about 150 r.p.m. by means of a relay operating from a current transformer in the stator circuits.

An ingenious arrangement of current transformers is utilized to act on the grid circuits and cause a phase shift independently of the speed controller and thus limit tube current. Due to this feature the motor can be accelerated from standstill to a present speed by throwing it directly across the line without danger of damage. It is thus inherently self-protecting, the overload relays on the oil circuit breaker acting solely as backup protection. Only twice rated full load current is taken under this condition.

For best operation the cathode heater potential should be lowered slightly as the load increases, since this tends to maintain a constant tube temperature. This is accomplished by inserting one winding of a saturable

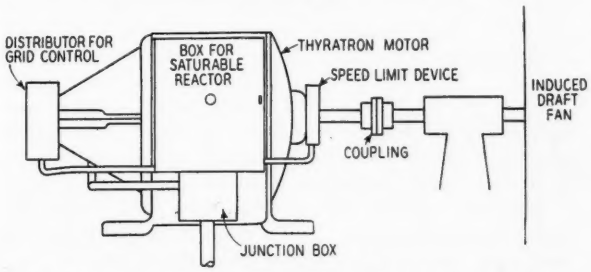


Fig. 1. Thyratron-controlled 400-hp. motor as installed at the Logan Plant

reactor in series with the heater circuit, the other winding being in series with the motor field. A third or saturating winding is excited from direct current. This saturable reactor serves a dual purpose, its other function being to initiate an alarm when a tube fails, as mentioned above.

Tube Disconnecting Feature

During the development of the control equipment it became evident that facilities would have to be provided for tube replacement while the motor was in operation. Since the anode potential is 2300 volts, safety to personnel had to be taken into consideration. Means had also to be provided for interrupting the anode supply before the tube was removed and this required a 2300-volt disconnecting switch capable of interrupting the normal tube current, since it was not considered advisable to interrupt the anode circuit at the separable contacts of the individual tube cell. This presented a problem on account of the limited space available. It was successfully solved by developing the fuse type of disconnecting switch by means of which the circuit is interrupted from the outside of the cubicle by the key which unlatches the door.

Operating Principles

The operating principles of the motor have been fully described in the April 1935 issue of Power Plant Engineering, but for the sake of completeness a brief review with reference to Fig. 2 may be helpful.

The motor, although structurally resembling a synchronous machine, functions like a d.c. series motor and has characteristics closely resembling such a machine. The field winding and each phase of each stator winding are traversed by a direct current, although the values of current in the stator coils differ in time phase.

A thyratron is a mercury-vapor hot-cathode rectifier tube. A positive grid voltage is essential to start the tube conducting, but once the current flows, the grid has no further effect and conduction will continue until the anode becomes negative with reference to the cathode. If the applied grid voltage is alternating, a shift in phase between the anode and grid voltages will delay the initiation of anode-current flow, decrease the amount of energy passed during the positive half cycle, and hence decrease the speed of the motor. From this it should be clear that the motor speed is independent of system frequency.

An open grid circuit will prevent tube conduction; therefore a distributor mounted on the motor shaft and connected into the grid circuits can control the time of firing of the tubes as a function of rotor position. Thus "commutation" can be attained. By connecting in parallel three tubes which receive their supply from a three-phase source, polyphase energy may be utilized for one stator phase subject to the control of the distributor. If the phase shifting and distributing features are connected in series, any tube can be controlled to fire at the proper time and for a desired

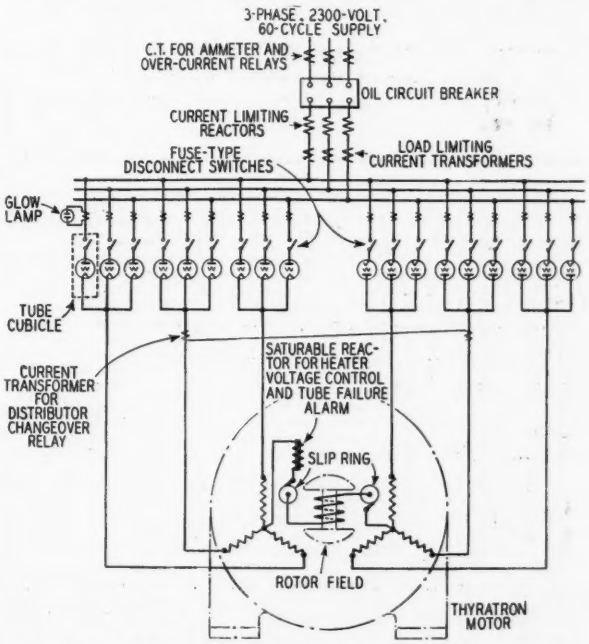


Fig. 2. Power connections for the thyratron-controlled motor

interval. Thus commutation and controlled rectification with- concomitant speed variation may be obtained within a single tube.

Installation Consideration

Figure 3 shows a typical arrangement of connections between the motor and its control equipment. It is evident that there is an advantage in keeping the cubicle close to the motor. However, it is also necessary that it be installed in as cool a place as possible in order to limit the tube temperatures to the recommended upper limit of 55 deg. C.

Since the motor has characteristics similar to a d.c. series motor, precautions against loss of load, however remote, must be taken and a speed-limit device interlocked with the primary breaker control should be installed. An additional safeguard is provided in a limit stop which is placed on the speed control dial so that the rated speed cannot be exceeded.

The saturable reactor previously described is mounted directly on the motor frame and enclosed in a sheet metal box, thus avoiding the use of additional high voltage power connections. It is recommended that the distributor selector relay be also mounted in this cabinet, thus materially lessening the number of control wires between the motor and cubicle.

Operating Experience

There have been so many references in the technical press to the pioneer installation of the thyratron motor as to lead to the belief that it has been running for a long time although it was actually placed in regular operation at the Logan power station of the Appalachian Electric Power Company on May 29, 1936.

During the year the motor has been in operation at this writing, a comparatively large number of minor difficulties arose. Yet in spite of these, the plant operators are very enthusiastic about its performance. Experience has shown them that no drive compares with it for ease of control, for smoothness of draft regulation, for ability to rotate at very low speed, and for almost entire elimination of fan blade maintenance expense. In view of the fact that plant operators are pretty hard-headed and tend to look with suspicion on new "gadgets," this response would seem convincing evidence of its success from a practical standpoint.

Table I. Thyratron Tube Failures, May 29, 1936, to July 31, 1937

Failure Number	Tube Service Hours of Operation	Time of Failure	Nature of Failure
1	191	While starting	Cathode heater burned open
2	679	While starting	Cathode heater burned open
3	787	While starting	Cathode heater burned open
4	1,079	During preliminary heating before starting	Cathode heater burned open
5	2,362	During preliminary heating before starting	Cathode heater burned open
6	2,862	While starting	Cathode heater burned open Grid destroyed
7	792	During preliminary heating before starting	Cathode heater burned open
8	3,576	During operation	Apparent short circuit in tube. Protective gap and capacitor destroyed
9	4,509	During operation	Cathode heater burned open
10	4,628	During preliminary heating before starting	Cathode heater burned open
11	5,440	During operation	Tube ceased firing for no apparent cause
12	5,829	During preliminary heating before starting	Cathode heater burned open
13	5,829	While starting	Tube ceased firing for no apparent cause
14	3,550	During operation	Tube ceased firing for no apparent cause
15	6,400	During operation	Cathode heater burned open
16	742	During preliminary heating before starting	Cathode heater burned open
17	7,106	During operation	Cathode heater burned open
18	2,053	During operation	Interior of tube completely destroyed
19	7,560	During operation	Tube ceased firing for no apparent cause
20	8,272	During operation	Cathode heater burned open

Table II. Operating Troubles with Thyratron Motor Accessories, May 29, 1936, to July 31, 1937

Failure Number	Interruption Time—Hours	Cause
1		Filament transformer burned out
2	192	Field coil burned out
3	84	Field coil burned out
4	1/3	Fuse type disconnect switch burned open
5	20	Ground on one stator phase due to cable rubbing against dowel pin
6		Fuse type disconnect switch pulled apart
7	1½	Protective gap and grid capacitor destroyed
8	1/3	Thyratron tube and protective gap destroyed
9	3½	Fuse type disconnect switch arced to ground. Replaced. Again arced to ground. Replaced
10	4	Ventilating fan motor burned out
11		Field coil showed evidence of charring
12		During boiler shutdown, new set of field coils installed, and bearings changed
13		Fuse type disconnect switch burned open
14		3 tubes fired irregularly. Brush on distributor made poor contact
15		Bearings worn due to erratic magnetic center Evidence of electrolysis causing bearing pitting. Corrected by placing brushes in contact with both ends of shaft, connecting together and grounding

Total: 306 boiler-hours lost.
Total hours of operation: 8,376.

The most serious difficulty has been with the thyratron tubes themselves. In 14 months of operation, 20 tubes have failed, almost all of them due to the opening of the cathode heater circuit. Table I summarizes these failures and Table II troubles from other causes. It is to be noted that the actual hours of motor operation represent a service availability of 84 per cent. This includes shut-down from all causes such as boiler and fan maintenance. Interruptions due to the motor alone took only 3½ per cent of the operating time and an availability of 96½ per cent may be considered a not unsatisfactory record for an entirely new type of control.

Discussion of Operating Troubles

Many of the difficulties encountered are of a nature which would make it extremely improbable that they will be encountered again. For instance the trouble with three field coils was evidence that the motor field was being subjected to unexpected surge voltages and that its original insulation was inadequate. When the entire set of coils was replaced by ones having greater insulation, no further trouble of this type manifested itself.

The pitting of the bearings and the unexpected thrust due to unbalanced magnetic forces causing excessive bearing lining wear and coupling troubles were completely cured by the installation of brushes bearing on the shaft and connected to ground.

Failure of parts due to arcing to ground have been corrected where possible by providing greater clearance and the experience gained from this can of course be incorporated in subsequent designs. The fuse-type disconnect switches leave some room for improvement, but they were an afterthought in the initial installation and probably a better type of device will be available for subsequent installations.

The grounding of a stator phase lead by rubbing against a metal dowel pin could have occurred in any machine.

Auxiliary transformers, protective gaps, resistors, condensers, blower motors, etc., are always possible sources of trouble. Filament and grid transformers operate at 2300 v. and clearances must be kept large to avoid creepage due to infiltration of conducting dust which is always present in a power plant. No doubt some of the smaller devices will occasionally fail from time to time, but they are comparatively inexpensive to replace and mostly of such a nature as not to cause an immediate shutdown in case of failure. Even these can be improved by careful attention to the requirements.

The thyratron tubes leave the biggest room for improvement. A large number of failures has resulted either while starting or during the preliminary heating period and tube designers should consider these facts. Without a doubt the fragility of the cathode heaters can be corrected. The very persistance of this type of failure should be a clue to the remedial measures necessary. Steps have already been taken in this direction by the use of flexible instead of solid connections at the cathode heater terminals within the tube.

Operation with Defective Tubes

Although defective tubes are replaced almost immediately during operation, it is interesting to note that no harmful effects occur if several tubes cease firing

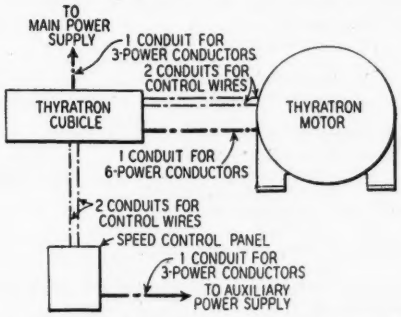

TO MAIN POWER SUPPLY
1 CONDUIT FOR 3-POWER CONDUCTORS
2 CONDUITS FOR CONTROL WIRES
THYRATRON CUBICLE
THYRATRON MOTOR
1 CONDUIT FOR 6-POWER CONDUCTORS
2 CONDUITS FOR CONTROL WIRES
SPEED CONTROL PANEL
1 CONDUIT FOR 3-POWER CONDUCTORS
TO AUXILIARY POWER SUPPLY

Fig. 3. Thyratron-controlled motor—typical arrangement of equipment and conduits

simultaneously. During factory tests as many as four tubes were removed simultaneously in various combinations, from different parts of the circuit, the only noticeable effect being a drop in speed and a slight irregularity in rotation. The motor will even start single phase (six tubes removed), although, of course, it will not attain full speed under this condition.

Tests were made with the cathode heater supply and grid control circuits suddenly interrupted to simulate blowing of fuses. Speed remained normal during the 15-second interval permitted by the cathode timing relay before shutting down the motor. Low primary voltage, sudden opening and closing of the primary breaker, and almost all possible combinations of interruption of main and auxiliary power supply were tried without any noteworthy change in operation except a decrease in speed or irregular rotation due to unbalanced torque. It would go hard with any operator who attempted at the plant any operation even remotely resembling the paces that the motor was put through at the factory.

Conclusion

Whether the thyratron motor is here to stay would seem to depend to a considerable extent on the tube designer. The operating principles of the motor are fundamentally sound; the control will undoubtedly be improved and simplified. This should aid in reducing the first cost of the motor to a competitive level, but tubes must be made more rugged if maintenance costs are not to be excessive.

Stopping Induction Motors With Direct Current

There are more ways of stopping a squirrel-cage motor than putting on a brake. Reversing two leads (plugging) is a time-honored method. Mechanical brakes are common. One method, the use of direct-current though not unknown, has been little used until recently. Applying a shot of direct-current across one phase of a running motor has, so to speak, a most retarding influence. Direct-current applied to the stator winding, in effect, greatly increases the eddy-current losses so the motor quickly stops. The energy of rotation is absorbed as heat losses within the motor.

A supply of direct-current is not always handy, and the installation of rotating equipment to produce it is not always justified. The Westinghouse rectox-type rectifier offers a simple, low-maintenance method of getting the braking-current direct from the alternating-current lines.

Two general schemes for using rectox-produced current for braking are being used; one uses a simple pushbutton that applies the direct-current as long as the button is held depressed. In the other a timing relay removes the direct-current after the motor stop. The general method has been successfully applied to machine-tool motors requiring as many as 15 stops per minute.

The same method of braking has been applied to rayon spinning motors. These are three-phase, two-pole motors, running on high-frequency at perhaps 8400 r.p.m. When the rayon buckets are full, quick stopping is desirable to decrease lost production time and to decrease the waste of yarn material. Previously these motors have been stopped by plugging, but requires that the operator watch them carefully to open the plugging circuit just as the motors stop, otherwise the motors will start in the reverse direction. Last year several metal-enclosed switchgear units were built by Westinghouse, each for the starting and stopping of spinning motors. The switchgear, built as a unit and installed with only external connections necessary, contains a three-pole breaker for the normal spinning operation and a two-pole breaker for applying the direct-current. Both are operated from a common handle so that proper sequence is assured. (From the Westinghouse Engineering Progress report.)

Construction of a new central heating plant by University of Kentucky at Louisville to replace 20 small scattered plants has resulted in estimated saving of $13,000 a year and steam cost of 39 cents per 1000 lb. This cost covers fuel, water, labor, superintendence, maintenance, interest, and sinking fund to repay the cost of building, equipment and pipe tunnels. This result has been accomplished by careful planning of the plant and selection of equipment to give correct combustion control and mechanical handling and control of fuel supply with a Link Belt system. Since it is to serve as a laboratory for engineering students as well as a heating plant, both stoker and pulverized fuel firing were included, with different types of boilers.

A. I. E. E. Meeting Emphasizes

Papers presented at the Winter Convention of the American Institute of Electrical Engineers in New York, January 24 to 28, reflect increasing usefulness of electronic devices in all branches of the electrical art.

NOTHING at the winter meeting of the American Institute of Electrical Engineers was more impressive than the great amount of attention accorded the electron tube as a useful device in all branches of the electrical art. Well over a third of all the technical papers presented at the technical sessions were devoted to systems or equipment involving the use of tubes in one form or another. Though he may not be directly conscious of it, the electrical engineer of today could not get along without the electron tube without considerably limiting his field of action. As a measuring instrument it enters into every branch of the art, and, to give an example, such a study of wood pole insulation strength as presented at one of the sessions by Philip Sporn and J. T. Lusiguan would be impossible without it; for the cathode ray oscillograph used in these studies is an electron tube.

So, if any one thing at this meeting stands out, to the writer at least, it is the growing importance of the electron tube, not only in the field of communication and measurement but in heavy power engineering.

Last year, it may be recalled, a considerable amount of attention was given the subject of tensors. This year, except for one or two papers involving the use of matrices in engineering tensors were noticeably in the background. Whether this implies the downfall of the intellectual royalists or whether Dr. Slepian's spoken and published remarks on tensors have sent all the tensor enthusiasts to the fruit salad business, we do not venture to guess. The chances are that the engineers are busy trying to assimilate the subject of tensors for they are becoming increasingly common in high brow electrical literature.

As always, it was an interesting meeting; not spectacular in any particular way, perhaps, but the papers were uniformly good and of sufficient diversity to attract a wide variety of interests. Department store accounting may seem far removed from the realm of electrical engineering but we changed our ideas about this at the opening session on communication when L. F. Woodruff presented his paper on electrical remote control accounting. Neither would it seem that studies of living tissue hold much of interest to electrical engineers but when such studies involve the relation between tissue response and voltage distribution as they did in a paper presented at the Electrical Measurements session, it becomes evident that they are as interesting to the engineer as they are to the biologist. Come to think of it now, the reaction of frog legs figured prominently in the early history of electricity. We refer to these two papers here to indicate the diversity of subjects which are engaging electrical engineers' attention these days.

Summarized Schedule of Principal Events

Monday, January 24
- 9:00 a. m. Registration
- 10:00 a. m. Communication
- Symposium on modern electric vehicles—I
- 2:00 p. m. Symposium on a new carrier telephone system for toll cable
- Symposium on modern electric vehicles—II
- Conference on radiation fields

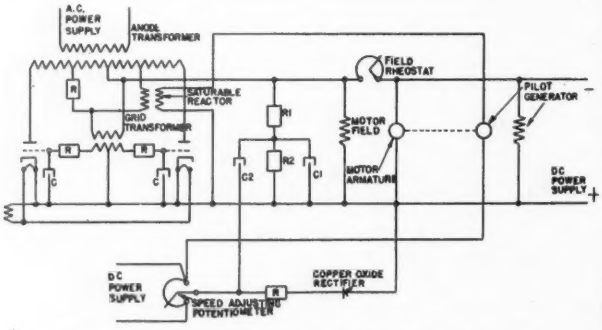
Tuesday, January 25
- 9:30 a. m. Lightning protection
- Symposium on electronics—I
- Conference on education
- 2:00 p. m. Relays and reactors
- Symposium on electronics—II
- Conference on sound and vibration
- 6:30 p. m. Smoker at the Commodore Hotel

Wednesday, January 26
- 10:00 a. m. General session
- 2:00 p. m. Instruments and measurements
- Electric welding
- Basic Sciences
- 8:00 p. m. Edison Medal presentation

Thursday, January 27
- 9:30 p. m. Power transmission
- Conference on network analysis and synthesis
- Electrical machinery—I
- Conference on Definitions
- 2:00 p. m. Television
- Cables and research
- Electrical machinery—II
- 7:00 p. m. Dinner-dance at the Plaza Hotel

Friday, January 28
- All day Inspection trips

Saturday, January 29
- 3:00 p. m. "Monarch of Bermuda" sails on post-convention cruise to Bermuda.

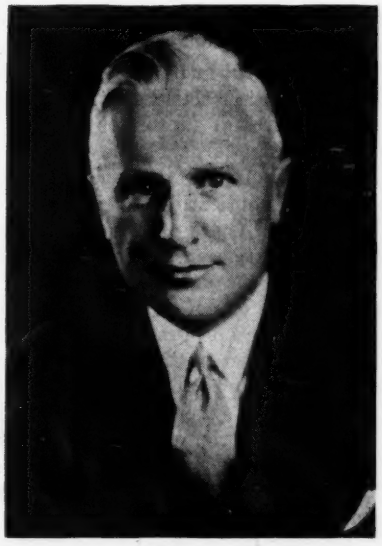


Thyratron Field Control Circuit for holding constant speed

General Plan of Meeting

Altogether there were 16 technical sessions, one general session and five conference sessions. The conference sessions were for the greater part technical, dealing with such subjects as education, field problems, network analysis, sound and vibration and such things

Growing Importance of Electronics



W. H. Harrison, President of the American Institute of Electrical Engineers, 1938

but they afforded groups of specialists an opportunity to meet and discuss subjects informally and without fear that their remarks would appear in print. These conferences are a relatively new feature at the A.I.E.E. meetings and the few that have been held have proved very successful. While formal papers are presented at these conferences, the object is by no means the discussion of the papers themselves but fundamentally an exchange of newer ideas and a discussion of research results on the topics considered.

The general plan of the meeting is shown by the accompanying schedule of principal events. The general session on Wednesday morning was devoted largely to an address by Dr. H. G. Moulton, President of the Brookings Institution, on Technological Development in Relation to Economics, but this was preceded by the presentation of the Alfred Noble Prize to Dr. G. M. L. Sommerman. This prize, which was instituted in honor of a past president of the American Society of Civil Engineers is given for a technical paper of particular merit and this year was awarded to Dr. Sommerman for his paper "Properties of Saturants for Paper Insulated Cables." Dr. Sommerman is research engineer for the American Steel and Wire Co. at Worcester, Mass.

The Edison Medal presentation to Gano Dunn took place at the Wednesday evening session, at which there was also a lecture on the New York World's Fair by Stephen F. Voorhees.

Neither of these two general meetings was particularly outstanding. Dr. Moulton's paper lacked the clarity and conciseness which would have been desirable in a discussion of this type and as one listened one wondered whether Dr. Moulton's findings were as impartial and unbiased by personal feelings as they were implied to be.

The Technical Sessions

It is obviously impossible in a brief report such as this to present even a superficial review of the 65 technical papers presented at this meeting nor is it desirable. Those that really want to know about any of them will find them easily available in the publications of the A.I.E.E., and many of them, naturally, are far removed from the interests of readers of this publication whose concern is primarily the generation and distribution of power.

Electronics

In many ways, the session of outstanding interest to power plant engineers was the first symposium on electronics on Tuesday morning, because this session was devoted almost entirely to papers and discussions on the Thyratron motor. The Thyratron motor, it will be recalled, was first announced several years ago and its features were described in a paper presented at the A.I.E.E. winter convention in 1934. At that time it was announced that a 400-hp. unit had been ordered for installation in one of the power stations of the American Gas and Electric Co.

The paper of greatest interest at this session, therefore, was one by A. H. Beiler of the American Gas and Electric Co., in which the author recounted the operating experiences with this motor, which, by the way, is installed at the Logan Plant of the Appalachian Power Co. A comprehensive abstract of this paper is presented on p. 188 of this issue, so it will not be discussed here. It is extremely interesting to know, however, that this motor has proved its merit in the first year of its operation. Naturally, there have been troubles but this could have been expected with a machine so radically different from anything that had ever been used before. Of particular interest is the enthusiastic reaction to this motor by the plant operators. No drive compares with it for ease of control and smoothness of draft operation and it has resulted in the almost entire elimination of fan blade maintenance expense. As pointed out in the paper, plant operators are pretty hard headed and tend to look with suspicion on new "gadgets", so this response seems convincing evidence of the success of this motor from a practical standpoint.

Another paper of great interest at this session was the paper by G. W. Garman, of the General Electric Co., on Thyratron Control of d.c. motors. This paper described the characteristics of new thyratron circuits which have been developed for the control of d.c. motors. By means of these circuits it is possible to hold constant motor speed, constant armature voltage, or constant relative speed between two systems. It is also possible to hold constant either an alternating or direct

current voltage which is dependent on the speed or position of the armature of a direct current motor. A circuit of this type is shown in the accompanying diagram, this being a field control circuit for holding constant speed. In this particular system which is only one of several, the speed determining means is a pilot generator and the standard of reference is the voltage drop in a potentiometer.

More general in its scope than either the papers by Messrs. Beiler or Garman, was the paper on Electronic Speed Control of Motors, by E. F. W. Alexanderson and M. A. Edwards of the General Electric Co. and C. H. Willis of Princeton University. This paper discussed the application of electron tubes to the speed control of all types of motors. As pointed out in this paper, the development of power tubes provides a new approach to the problem of variable speed motors. It appears to be one of the most promising fields for large tubes and rapid progress may be expected in this direction. This paper outlined three of the more promising methods of using tubes to control the speed of motors. These were the synchronous motor using Thyratrons as a commutator[1], the wound-rotor induction motor using a rectifier and a d.c. motor on the secondary, and a phase-controlled rectifier supplying a d.c. motor from an a.c. power source.

A fourth paper at this session dealt with the use of Phanatron rectifiers as a source of d.c. supply for elevator motors. This paper by Clymer and Lorraine of General Electric indicated the advantages of this form of direct current supply over motor generator sets in buildings where the existing direct current supply is changed to alternating current. Such rectifying sets are 10 per cent more efficient than the corresponding motor generator set, they are of lower first cost, and need no skilled supervision. Seven such installations have been placed in operation in the Chicago area during the past two years and all of these have given remarkably good service.

Naturally, all of these papers on electronics were received with considerable interest and there was a fair amount of discussion. With regard to the Thyratron motor at Logan, Philip Sporn said that everything expected in the way of performance had been realized but the electron devices themselves had not stood up. This, of course, was to be expected, he said, and as he has pointed out frequently before, until such tubes are used and manufactured in larger quantities, we must expect them to give trouble.

Irving Moultrop contributed to the discussion in pointing out that they—The Boston Edison—were the pioneers in the use of electron tubes for power use and that they had installed a Phanatron rectifier in one of their substations about 8 yr. ago. This installation, he implied, had proved unsuccessful.

To one who was in some degree familiar with this Boston installation, this lack of success it seems was not entirely because of the equipment itself but also perhaps to lack of enthusiasm or faith in a new development of this type. To attain success with a new device one must believe in it and be willing to put up with a certain amount of "grief". Mr. Moultrop admitted that they had bought the "outfit" largely because of the eloquence of his good friend, C. W. Stone of General Electric.

Sporn's attitude is neither one of belief nor disbelief in these electronic devices, but he is willing to experiment with them and to assist in every way in determining their capabilities.

[1]The method used in the Thyratron Motor at the Logan Plant. See page 188 in this issue.

Communication

Recent developments in the communication field were discussed at two sessions, one devoted primarily to a consideration of the new broad band carrier transmission systems for toll telephone cables. No person not closely associated with developments in the communication field has any conception of the enormous strides made in this field in recent years. Such broad band systems involve a principle, not new in telephone work, but which has been perfected to the point where as many as 240 separate telephone conversations can be carried simultaneously over a single pair of wires. At this session a preliminary discussion was given by H. A. Affel of the Bell Telephone Laboratories which served as an introduction to the other four papers presented. One of these described the carrier system itself, one the terminal equipment, a third the crystal channel filters for the system and the fourth was devoted to a consideration of cross talk and noise on the new system. While these systems embody every modern idea known in the telephone art, one of the most outstanding is the use of quartz crystal filters to confine the transmission of groups of frequencies within certain limits.

These papers were remarkable in the almost inconceivable complexity of the system described. No author of an "Alice in Wonderland" or an "Arabian Nights" could ever have imagined anything more wonderful than these circuits which so effectively mix 240 separate and distinct voice frequency messages together, transmit them over a cable and then unscramble them at the other end.

And this is not the end; as was brought out in the discussion, at the present time the Bell engineers are working to extend the range of this system to two megacycles or 480 telephone conversations.

The first session on communication was of a more general nature than the one just referred to, since it was concerned with printing telegraph operation, coupling action between parallel circuits and electrical remote control accounting. One might wonder why a paper dealing with accounting is placed in a Communications session, but after we found out what it was all about we concluded that that was perhaps the most logical place for it.

This paper, presented by L. F. Woodruff of M.I.T., described the application of the central record system to department store operations but, as was pointed out by the author, no great stretch of imagination is needed to visualize the application of this system and its devices to other fields including factory production control and pay rolls, public utility accounts receivable, and others. The system involves a number of transmitters, located at various points in the store where sales are made, connected electrically with a central records recorder and operated in conjunction with tabulating and sorting machines. The initial operation at the time the sale is made is practically the only opera-

tion; from there on nearly everything is done automatically, including the making out of the customer's monthly bill. It is uncanny in its accuracy and speed of operation and while it is expensive to install, in a large organization it would seem to have definite advantages which would justify the cost of installation.

Despite the varied and interesting nature of the papers at this session, discussion was lacking and weak. One or two questions were asked but there was little or no enthusiasm. The best discussion was a written one, sent in by Prof. E. E. George of the Tennessee Power Co., who discussed the paper describing the new single-carrier telephone system by Fisher, Olmquist and Mills of the Bell Telephone Laboratories. Professor George wrote that the Tennessee Power Co. had leased one of these new carrier systems, known as the Type H, for use on a 167 mile line on their power system. Notwithstanding the fact that this telephone line was a hot line paralleling the 110,000 v. power line, he said it was the most quiet and best operating telephone system they had ever used.

Quite different in the amount of enthusiasm displayed was the first session on Modern Electric Vehicles. There are, no doubt, good reasons for having them but we have always thought it unfortunate that simultaneous sessions have to be held at a meeting of this type, since there are always some sessions which one would like to attend even though one's interest in them may be only general.

This was certainly true of the two full sessions on Modern Electric Vehicles held on Monday simultaneously with the Communication session. These were, of course, of primary interest to the transportation group but since all of us travel on street cars and buses more or less regularly these sessions were of general interest to everyone at the meeting. Street cars and trolley buses as well as Diesel electric buses have all undergone remarkable development in recent years and the papers presented at these sessions gave one an idea of what these developments were. All of the papers were excellent and the discussion was keen and animated.

Electron Tubes in the Field of Measurement

In the field of measurement as well as in nearly all other branches of the electrical art, the electron tube is extending the field of action. This was brought out with particular emphasis by a paper at the Instruments and Measurement session by H. A. Thompson of G. E. Mr. Thompson described a new stabilized amplifier for measurement purposes. As he pointed out, with electron tube amplifiers it is possible to measure smaller quantities than ever before. It has been found, however, that when an ordinary amplifier is used to extend the sensitivity of an indicating instrument, such as a voltmeter or ammeter, the accuracy, reliability and ease of operation of the amplifier does not begin to approach that of the indicating instrument. It was because of these shortcomings of existing types of amplifiers that the new stabilized amplifier described by Mr. Thompson had been developed. This amplifier incorporates the feedback principle first described by H. S. Black of Bell Telephone Laboratories, at the A.I.E.E. winter meeting in 1934. With this principle, the amplifier is deliberately built with several times the necessary amplification and then, by feeding a portion of the output back on the input in such a way as to throw away the excess amplification, the amplifier acquires new properties, the most important of which is constancy of amplification and freedom from non-linearity. With the amplifiers described, using this principle, Mr. Thompson stated that electron tube amplifiers can now be built that are just as accurate and reliable, and in many respects better than, the indicating instruments with which they are to be used.

Power Transmission

At the power transmission session on Thursday a motion picture of unique character was shown by L. F. Woodruff of M.I.T. This picture was of the animated type but portrayed transmission line transients in a way that would have made it clear to one having even a superficial knowledge of the subject. The picture had been developed by means of studies made with the cathode ray oscillograph on an artificial transmission line. It is one of a series of educational films being used in the engineering courses at M.I.T.

Other papers at this session were mostly of a highly specialized nature, though the one on the Lightning Strength of Wood in Power Transmission Structures by Sporn and Lusiguan was of general interest to all power engineers. By means of cathode ray oscillographic studies of impulse flashovers on a number of wood pole structures the authors show how the insulation value of such structures could be predicted quite accurately.

As already mentioned, in addition to the regular technical sessions a number of conferences were held at which technical matters were discussed. These conferences were very well attended and the discussion much more vigorous than at the technical sessions. While several of these conferences dealt with rather abstract matters, the one on Sound and Vibration Measurements was of quite general interest. The paper by A. P. Fugill of the Detroit Edison Co. on Experiences With Noise Specification Tests presented at this conference was of particular interest in that it dealt with a practical application of sound measurement in the power field; that is in the measurement of transformer noise. There is seemingly much more to be done yet in this field, especially as regards standard meters for the measurement of absolute sound values. V. L. Chrisler of the Bureau of Standards related the experiences of the Bureau in testing several of the sound meters now on the market and showed the wide variation in these readings. A proposed test code on Apparatus Noise Measurement was reviewed at this meeting and further suggestions made.

As always there were numerous inspection trips to fulfil a variety of interests. To power engineers, the trips to Waterside Generating Station and to the grid controlled rectifier installation on the Third Avenue Railway System were of particular interest.

As was the case last year, there was a post convention cruise to Bermuda but of course only a small number of the 1300 odd total registration could avail themselves of this luxury.

The last day of the meeting was given over entirely to inspection trips.

DEGREE-DAYS

Steam and Coal Needed

TO SIMPLIFY the estimation of steam or coal required for heating a building, the degree-day method has come into common use. From observation it has been determined that heat required varies as the difference between outdoor temperature and 65 deg. F., when usual inside temperature is maintained. A degree day is defined as a difference of 1 deg. between the average outdoor temperature for 24 hr. and 65 deg., or for an average outside temperature of 30 deg. a day would count as 35 degree-days.

The total of degree-days for the heating season gives the yearly degree-days on which steam or coal needs is estimated.

Amount of heat needed yearly for a building will vary with the cubic contents of the space heated and the yearly degree-days for that locality. This is, of course, approximate since construction, exposure, ratio of exposed area to cubic contents and type of exposed surface will affect the requirements, but the method will give a reasonable approximation and the result can be increased for bleak exposures, thin walls, long, narrow buildings and large amounts of window area. A more accurate method is to compute the thousands of B.t.u. loss per hour, but this requires considerable work.

Yearly degree-days for various localities are given in Table I, from which the amount for any locality can be estimated with fair accuracy. These values are from Air Conditioning Blue Book and the A.S.H.V.E. Guide. Evidently, the heat needed will depend on the kind of building and its construction, and Table II gives the steam needed per degree-day for various types of building, per 1000 cu. ft. of heated space. Knowing location, kind of building and cubic feet to be heated, the steam requirements can be quickly figured. To convert into coal, having heat value of 13,000 B.t.u. per lb. and with efficiency of 60 per cent, allowing for radiation and other losses, 1,000,000 lb. of steam may be taken as calling for 80 t. of coal.

As an illustration, for a factory in Cleveland, Ohio, having 100,000 cu. ft. to be heated, the degree-days will be 6125 and steam per degree-day per 1000 cu. ft. will be 0.90 lb. Steam per season will be $6125 \times 0.90 \times 100 = 551{,}250$ lb. Coal required will be $0.551 \times 80 = 44.1$ t.

From Table II it will be noted that, for the average of most types of buildings, steam needed for heating is about 1 lb. per degree-day per 1000 cu. ft., or 0.001 lb. steam per cu. ft. On this basis the steam needed, and coal of 13,000 B.t.u. at 60 per cent efficiency needed, per cu. ft. per season are given in Table III for various yearly degree-day requirements, so that from Table I and Table III, a fairly accurate estimate can be made for average requirements in all commercial buildings. For residential buildings, the results should be increased 50 per cent and for stores, storage and the like, decreased 50 per cent.

(Continued on page 199)

TABLE I. DEGREE-DAYS FOR VARIOUS LOCALITIES

Location	Months of Heating	Yearly Degree Days	Location	Months of Heating	Yearly Degree Days
Ala. Central	6	2410	N. J. East	8	5215
Ala. Southern	5	1470	N. J. West	8	4935
Ariz. North	10	7145	N. M. North	9	6065
Ariz. South	6	1845	N. Y. S.E.	8	5350
Ark. Central	7	2740	N. Y. Central	9	6835
Calif. Central	9	3265	N. C. North	7	3260
Calif. South	7	1505	N. C. S.E.	7	2300
Colo. Central	9	6215	N. D. South	10	8500
Conn.	9	5970	Ohio North	9	6125
D. C.	..	4595	Ohio South	8	5130
Fla. North	5	900	Okla. Central	7	3720
Ga. North	7	2890	Ore. N.W.	10	4515
Ga. S.E.	5	1490	Pa. East	9	4855
Idaho	9	4740	Pa. West	9	5280
Ill. North	9	6300	R. I.	9	6065
Ill. Central	8	5370	S. C. North	7	3260
Ind. Central	8	5315	S. C. South	6	1770
Ind. South	7	4165	S. D.	10	7450
Ia. North	9	7025	Tenn. North	7	3560
Ia. Central	8	6420	Tenn. West	7	2950
Kan. East	7	5290	Tex. Central	5	1370
Kan. West	8	5035	Tex. N.E.	6	2450
Ky. East	8	4615	Tex. S.E.	6	1125
Ky. West	7	4270	Utah North	9	6735
La. South	5	1025	Utah Central	9	5455
Me. East	10	8605	Vt. North	10	7875
Me. S.W.	9	7010	Va.	7	3775
Md. East	8	4565	Wash. West	10	5065
Mass. East	9	6050	Wash. Central	9	6350
Mass. West	9	6465	W. Va. Central	7	4950
Mich. South	9	6350	W. Va. North	9	5815
Mich. North	10	8695	Wisc. N.E.	9	7715
Minn. South	9	7900	Wisc. S.E.	9	7370
Minn. North	10	9480	Wisc. West	9	7290
Miss.	5	1825	Wyo. S.W.	9	7415
Mo. West	8	5205			
Mo. East	7	4585	CANADA		
Mont. North	9	8700	B. C. Vancouver	10	5975
Mont. South	9	7050	Man. Winnipeg	10	11165
Neb.	8	6231	Alb. Med. Hat	10	8155
Nev. West	10	5890	Ont. Pt. Arthur	10	10805
Nev. S.E.	9	6070	Ont. Toronto	10	7735
N. H. South	10	7095	Que. Montreal	10	8415

TABLE II. STEAM PER DEGREE-DAY PER 1000 CU. FT. HEATED

Kind of Building	Lb. Steam per Degree Day per 1000 cu. ft. Heated
Apartments*	1.78
Residences and Hotels*	1.40
Printing	1.25
Offices	1.00
Clubs, Stores, Theaters and Lofts	0.90
Banks	0.88
Churches and Dept. Stores	0.58
Garages	0.42

*Includes heating of water

TABLE III. STEAM AND COAL PER SEASON PER CUBIC FOOT HEATED

Yearly Deg. Days	Needed per Season per Cu. Ft.	
	Lb. Steam	Lb. Coal at 13,000 B.t.u. 60% Eff.
3000	3.0	0.48
3500	3.5	0.56
4000	4.0	0.64
4500	4.5	0.72
5000	5.0	0.80
5500	5.5	0.88
6000	6.0	0.96
6500	6.5	1.04
7000	7.0	1.12
7500	7.5	1.20
8000	8.0	1.28
8500	8.5	1.36
9000	9.0	1.44
9500	9.5	1.52
10000	10.0	1.60
11000	11.0	1.76

Rubber Mountings Step Into Industry

Silent operation of power equipment is being demanded by many industries for specific locations. The answer to a large number of these problems is found in vibration absorbing mountings which are treated in this article

By WALTER C. KEYS

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U. S. Rubber Products, Inc.

Fig. 1. Illustration of the principle of vibration absorption

PROPERLY utilized rubber is helping plant engineers, as well as product engineers, to solve many very troublesome problems in connection with vibration, transmitted noise, impact, the connecting of relatively moving parts of mechanisms, reduction of wear due to abrasion, prevention of corrosion, etc. Indeed rubber has now become a structural material capable of sustaining heavy loads for long periods of time.

Properly compounded rubber possesses the following useful properties:

1. It may be deformed either in compression or shear without any surface abrasion whatever.
2. It is a very poor conductor of sound.
3. It can be firmly bonded to steel and many other metals.
4. Impacts against it are not accompanied by great noise.

A few general laws are known as to the performance characteristics of rubber and may be used to predict how rubber will deflect when loaded under certain conditions.[1] Due to the fact that rubber can be used to absorb mechanical vibration while at the same time it does not transmit the noise of mechanisms, it is extensively used for this purpose and is right now moving into a wide variety of new uses in many industries.

Rubber, for structural purposes, is stressed in compression or in shear. In compression it will carry heavy loads with small deflections, while in shear it will carry lighter loads with large deflections.

Rubber in shear is usually bonded to and between parallel plates of low-carbon steel. Such a combination is known as a "shear sandwich." In use, one plate is secured to a support while the other plate is secured to the "sprung member." Both plates are usually in vertical planes, and gravity causes one plate to move downward (in its own plane) with respect to the other.

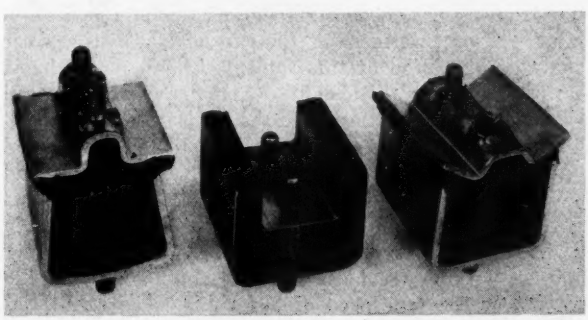


Fig. 2. Results of tests to determine bonding strength

Vibration Absorption

The principle of vibration absorption, while very old, is still not too well understood by many practical engineers whose work has not brought them into intimate contact with it. I have found it most effective to illustrate the principle by supporting a small weight on a long rubber band similar to the familiar toy shown in Fig. 1. If the hand is held still and the weight is caused to vibrate freely up and down, it will do so at a relatively slow rate. natural frequency. If then the hand is moved up and down at a relatively very rapid rate, forced frequency,

[1] "Rubber Springs" by Walter C. Keys, published in "Mechanical Engineering" May, 1937. Reprints available upon request.

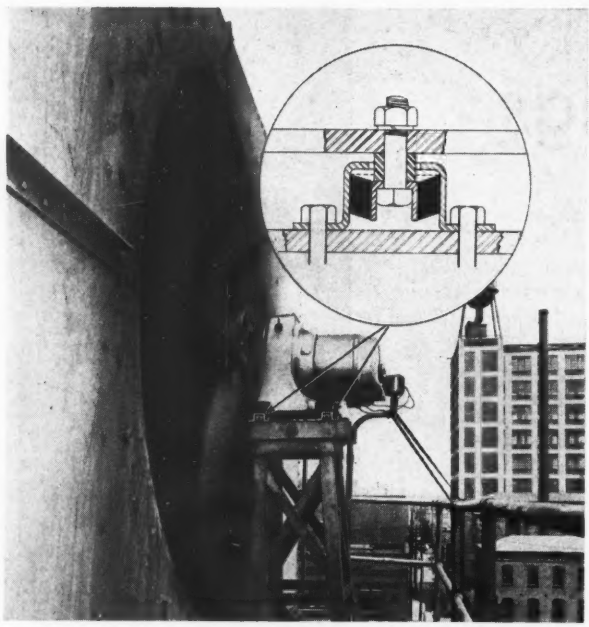


Fig. 3. Mounting of cooling tower fan to prevent noise

the weight will remain practically unmoved. This typifies vibration absorption through resilient media, and this principle has been used with varying success for many years for such familiar purposes as the riding qualities of automobiles, railroad cars and horse-drawn carriages.

If the hand is moved at the same rate as that at which the weight naturally vibrated, natural frequency equal to forced frequency, the condition of "resonance" exists, and the weight will move through a greater amplitude than the hand. Thus in this condition the resilient medium does not absorb vibration, but greatly amplifies it, and is worse than if none at all were used. Where the static deflections of supporting resilient members are small, the natural frequency of vibration will be rapid; large deflections result in natural vibrations at a slow rate. This is readily demonstrated with the toy: if the ball is supported through the full length of the rubber band the stretch or deflection is large and the vibration rate is much slower than when the band is grasped only an inch or so above the ball.

The relationship between static deflection and natural frequency of vibration is known (number of vibrations per minute = 188 ÷ static deflection in inches) and charts showing the values are available.

Excellent results in the way of vibration absorption will be obtained if the forced frequency is four times the natural frequency. Results are good if the ratio is 2½ to 1 but lower ratios give poor results.

Since the vibrations of industry in general are comparatively rapid, it has been practicable to produce a number of standardized resilient rubber mountings which effect satisfactory insulation for many kinds of mechanisms. Where the requirements for mountings run into the hundreds or thousands per week, however, it is usually advantageous to design mountings to fit exactly the requirements. It has been possible so to design adhesion mountings, that even though the adhered rubber were entirely destroyed by fire or extreme abuse, complete failure could not occur without first smashing metal parts of the mountings. This feature is particularly important in railroad equipment, ships, and in all cases where motors, etc., may be located above the heads of people.

The strength of the bond between rubber and metal is illustrated by Fig. 2. In the middle is a channel-shaped mounting ready for use. On either side are two such mountings after being "pulled" in a testing machine. Note that the inner channels (⅛ in. thick mild steel) have turned inside out although the rubber has not yet been completely pulled apart. A minimum bond strength (under such a test) of 200 to 250 lb. per sq. in. is readily obtainable. It is good practice to limit the load on the bond to 25 to 50 lb. per sq. in.

Use of Cellular Rubber

An exceedingly high grade of cellular rubber, known by the trade name of "Permacell," now available, offers new possibilities to engineers and architects. Unlike solid rubber, this material is compressible and offers outstanding advantages where entire floors or foundations must be carried on free-acting, resilient supports, also where required large deflections are not readily obtainable with rubber in shear.

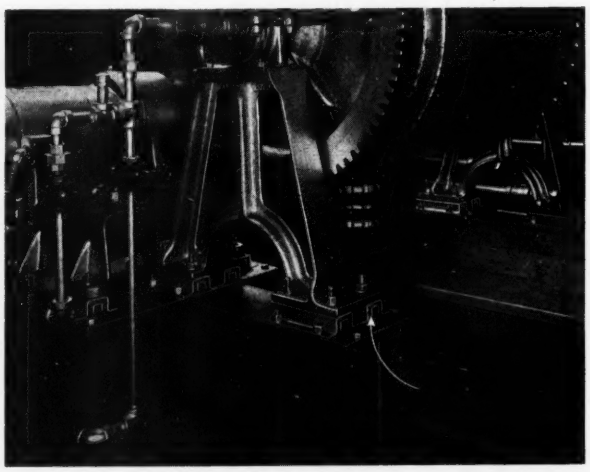


Fig. 4. Mountings to eliminate vibration in grinding mill

Typical of many successful applications of rubber mountings, the following cases are given:

A large airplane type of fan, Fig. 3, driven through a reduction gear was being used to supply air to a water cooling tower. The whine of the gearing was so loud that it was offensive to people located more than a mile away.

Analysis of the condition showed that the gear teeth were coming into mesh at the rate of 29,240 times per minute. Vibration at this rate produces a note almost an octave higher than middle C on the piano. The fan was metallically connected to the steel walls of the cooling tower, and these walls, acting like a huge loud speaker, amplified the vibration into a tremendously loud noise.

The engineers prescribed mountings loaded to obtain a deflection which would absorb 29,240 vibrations per minute without resonating at the motor speed of 1720 r.p.m., or the fan speed of 384 r.p.m. The result was highly effective. The fact that this mechanism was

located directly above a street made it obviously necessary to use safety mountings.

The vibration of a ball mill, used by a large manufacturer of toilet articles brought complaints from people in the same building, four stories below. The entire mechanism was placed on resilient mountings as shown in Fig. 4 which eliminated the cause for complaint.

A movie theater was troubled with disastrous vibration resulting in blurred pictures. Investigation pointed to the arc generators. When these had been installed, as indicated in Fig. 5, on mountings which afforded the proper static deflection, the trouble, which had of course been transmitted vibration, completely disappeared.

Transmitted noise from an elevator mechanism caused too frequent vacancies in apartments near the penthouse. An ineffective organic type of insulation was removed from under the mechanism base; shear-type, safety mountings were installed, as shown in Fig. 6, so as to support the entire weight of base, motor, gear unit, brake cables, counterweights, car and occupants. The contactor panel was also similarly mounted. This treatment was so effective that the person who had complained most seriously was unable to hear the elevator operate.

Nearly 6 yr. ago, several machine tools in the New Physics Building of Massachusetts Institute of Technology were installed on concrete foundations which had been poured onto slabs of Permacell rubber, it being essential not to transmit shock and vibration of these machines to the rest of the building. One of these slabs, approximately 8 ft. by 20 ft. in area, supports 44,000 lb. To date, no permanent set of the Permacell material has occurred.

More recently it was decided to insulate an extremely noisy tissue-rolling machine in the plant of a large paper company. This machine almost drove people out of offices located directly under it. An installation of Permacell under the base rendered it barely audible.

This latter case is typical of many wherein the insulation overcomes the transmission of noise through such a medium as a wall or floor. It is to be noted that the air-borne noise audible to people standing beside the machine is usually not appreciably affected by such a treatment.

In designing the applications of resilient supports certain general precautions should be observed.

1. Avoid short-circuiting the mountings by through bolts, connecting piping or other metallic connections.

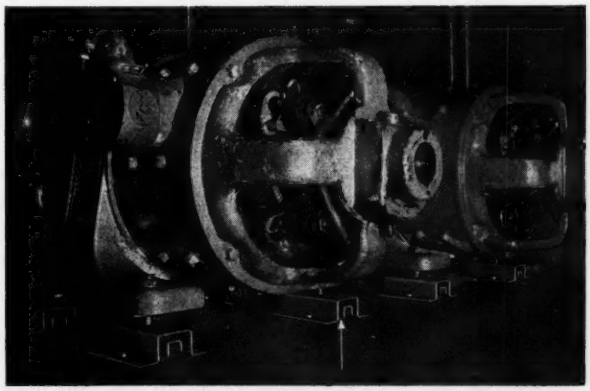


Fig. 5. Generators in motion picture theater mounted on rubber

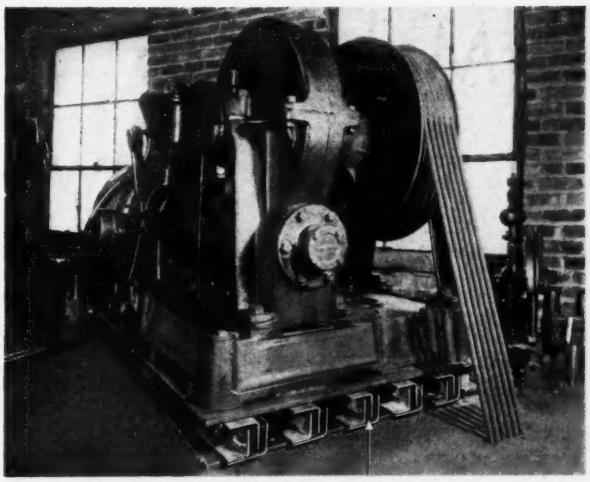


Fig. 6. Transmitted noise of elevator mechanism was practically eliminated by rubber mountings

2. Where possible, protect the rubber mountings from temperatures over 150 degrees F., from oil, sunlight and ozone. If the rubber is adhered to steel, the latter should not be exposed to corrosive chemicals. Brass or monel metal can be used instead of steel where necessary.
3. Arrange mountings properly to resist belt tension.
4. On vehicles it is frequently advisable to locate the mountings substantially in a horizontal plane through the center of gravity of the sprung unit, to prevent tipping of the latter due to large horizontal forces.

When used in a manner advantageous to the rubber, a life of 2 to 10 yr. can be expected. This is familiar to the users of all American passenger automobiles which employ rubber mountings on the most extensive scale in the world's history.

Vibration, abrasion and corrosion are destructive to metal. Rubber is benefited by moderate vibration, it resists abrasion and is practically unaffected by water and many chemicals. Rubber is the friend of mechanism.

Degree-Days

(Continued from page 196)

For coal other than 13,000 B.t.u. or for other than 60 per cent efficiency, coal values needed are found by proportion, i.e. for 10,000 B.t.u. coal, coal needed will be 1.3 times that from the table; and for 50 per cent efficiency coal needed will be 6/5 times that from the table.

For the example given, using Table III, steam needed would be

$$\frac{6 \times 6125}{6000} \times 100{,}000 = 612{,}500 \text{ lb.}$$

and coal needed would be

$$\frac{0.96 \times 6125}{6000} \times 100{,}000 = 98{,}000 \text{ lb.} = 49 \text{ t.}$$

Since this is a factory, 0.9 these values should be taken, or 551,250 lb. steam and 44.1 t. coal, which values agree with the previous method.

Make Up Your Own Steam Balance

A quick recipe for steam power plant operators of manufacturing establishments, office and loft buildings, hotels, and other types of buildings

By MARION S. BART

MANY chief engineers, plant operators and building superintendents undoubtedly have often asked themselves this puzzling question: "Where does my steam go to"? That question may be answered very simply by means of a steam balance, which at a quick glance shows not only where the steam goes but how much of it goes there, and brings out vividly and inefficiencies in plant operation.

Here is an easy way to make up your own steam balance. Write down on a sheet of paper in one column all of the items which make up the high pressure steam uses, then the items which make up the low pressure steam uses. Split up the quantity of steam used by these items according to winter and summer usage, in terms of thousand pounds of steam, and fill in these quantities opposite each item. Each item, including the total amount of steam generated by the boilers, is known except one, and that is the additional amount of live steam used for building heating during the winter to supplement the exhaust steam used for that purpose. Inasmuch as no steam is used for building heating during the summer, all summer items are therefore known and the sum of these items should equal the total steam generated in the summer. This is the key to the whole story. If these items are not equal, then something is wrong. As plant operator, you then realize that your plant is not as efficient as you thought it was and you have to go back and scrutinize each item and each piece of equipment. If on the other hand, these items are equal then go on to completing the winter column. Fill in the unknown item. This item of additional live steam is obtained by difference, namely, by subtracting the sum of the known winter items from the total steam generated during the winter. You then know that your winter items do balance and that the additional live steam item is correct, because the summer items balance. All you have to do now is add up the winter and summer uses opposite each item to get the total yearly usage for these items. This completes the high pressure steam balance.

Having satisfied yourself to some degree from the above steam balance that your high pressure equipment is operating satisfactorily, no doubt you are just as interested in knowing how efficiently the exhaust steam from this equipment is being utilized. The low pressure steam balance will tell you that. And here is how the low pressure steam balance is made up. You already know how much exhaust steam is available from the piston equipment, but you don't know how much of that steam is actually used or usable. Therefore, subtract the additional live steam for heating from the total low pressure uses, and the difference gives you the exhaust steam actually usable. The per cent of the available exhaust which is actually used—or usable divided by available exhaust—is your exhaust steam utilization efficiency. This is the key to your exhaust steam problem, and tells you how well the exhaust steam is being utilized in your plant. The difference between the usable and the available exhaust gives the amount of steam going to the stack or wasted to the atmosphere. This loss is due mostly to the diversity of usage between the piston equipment and the low pressure requirements. If we now take a small percentage of the steam used by the piston equipment as being wasted and add it to the exhaust steam loss, and consider this sum as water, we have the total amount of water which is wasted by the plant and which is to be made up as feedwater to the boilers. The amount of make-up water thus obtained should serve as a check on the metered quantity to the boilers. This completes the low pressure steam balance.

You now have a complete picture of your steam power plant operation and are now ready to interpret the results. Perhaps the first thing to look for is the item of additional live steam. If the amount or percentage of additional live steam appears reasonable as compared with the total steam generated, then all is well with your steam balance and your plant. But if this percentage appears unreasonably high to you, then it may be due to one of a number of things, two of which are as follows. First, that you have hardly enough exhaust steam to start with, in which case there is very little you can do under the existing conditions. Second, that you do have enough exhaust steam but that it is being used inefficiently. Your task then begins in checking back over the method of arriving at the total steam generated and going over each item of low pressure usage piece by piece. Next you should inspect the method of arriving at the exhaust available and recheck the exhaust usable. This involves quite a lengthy process. It serves a twofold purpose, however. It serves to improve your equipment operation and at the same time improve your steam balance. On the other hand, you may not desire to do all this, but may feel satisfied in simply jotting down the steam items

on paper and thus obtaining a rough idea as to what your steam balance looks like, and how your plant behaves.

The making up of your own steam balance therefore should enable you to improve the efficiency of your plant and thereby effect material operating savings heretofore not apparent. Do this each month for the entire preceding year and as a result you will obtain a month to month picture of your plant behavior. You can then compare the plant efficiency each month with that of the preceding month, and get to know the peculiarities and quickly remedy them.

The following example of a typical steam balance illustrates what has been said, and shows the simple steps to be taken in making up your own steam balance.

STEAM BALANCE

Item	*Thousand pounds of Steam* Winter	Summer	Total
High Pressure			
CO_2 Refrigeration Compressor	6,680	6,620	13,300
Generators	17,800	8,200	26,000
Boiler Feed Pumps	1,430	570	2,000
Vacuum Pumps	450	....	450
*Sump Pumps	....	....	....
House Pumps	4,240	2,110	6,350
Piston Equipment Steam	30,600	17,500	48,100
Process Steam	4,600	2,100	6,700
Additional Live Steam	12,400	....	12,400
Total High Pressure Uses	47,600	19,600	67,200
Low Pressure			
Building Heating	22,600	....	22,600
Hot Water	7,500	3,800	11,300
Feedwater Heating	3,100	1,300	4,400
Total Low Pressure Uses	33,200	5,100	38,300
Exhaust Steam Utilization			
Exhause Steam Available	24,500	14,000	38,500
Exhaust Steam Usable (85%, Winter)	20,800	5,100	25,900
Exhaust Steam Wasted	3,700	8,900	12,600

Water Wasted

12,600+4800 (10% Piston Equip.) = 17,400 thousand lb.

$$\frac{17{,}400{,}000}{62.5} = 278{,}304 \text{ cu. ft.}$$

*Negligible.

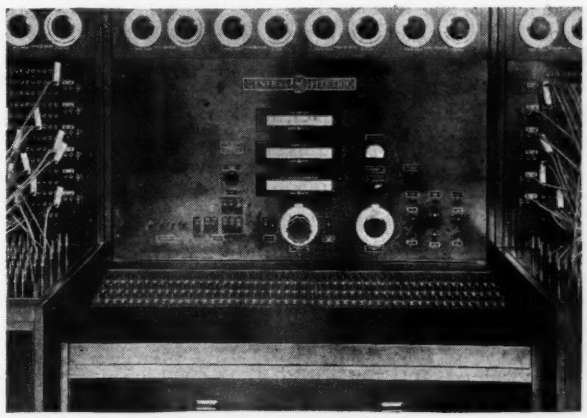
As noted, the steam balance is in terms of thousand pounds of steam. You may, however, by convention, use almost any unit, such as tons of coal, gallons of fuel oil, B.t.u.'s, or unit quantities in terms of the product manufactured or dealt with. It has been assumed in this discussion that the items of high or low pressure uses were known to start with. These items may be metered or estimated. The first is of course preferable. For the less exacting plant operator, however, and also for the sake of speed and economy, it is often necessary to estimate them.

Improved A.C. Network Analyzer

A NEW, improved, alternating-current network analyzer on which can be simulated networks in miniature representing lines and equipment on a utility company's system has been put into operation in the Schenectady Works of the General Electric Company.

The new analyzer may be operated by one man and can be used for load and voltage-regulation studies, investigations in system stability, and network studies involving mutual reactance. Setups may be made on the board for complicated equivalent circuits as well as short-circuit and relay conditions where greater accuracy is desired than it is possible to obtain with a direct-current calculating table.

The analyzer consists of a central metering and main control cabinet, two centrally located plugging cabinets, and eight cabinets which contain the various impedances used in setting up the network. The power source is a 480-cycle motor-generator set. The central cabinet contains the master ammeter, voltmeter, and watt-varmeter, together with operating switches and complete control to permit direct measurement of current, voltage, power, reactive power, phase angle and vector component of current and voltage at any given point in the network.



Network Analyzer

Silver contact switches are provided at the central control cabinet so that a single operator may insert the master instruments in any part of the impedance network and obtain any of the above measurements.

The network simulated is obtained by plugging various impedance units and sources of power from the plugging cabinets immediately adjacent to the instrument cabinet. The entire equipment is housed in steel frame cabinets with front panels of aluminum alloy. All panels are of the dead front type and are equipped with control knobs and dials for adjusting the units.

High accuracy is stressed in the component parts of the new analyzer. Outstanding are the master instruments which are of the light-beam type. They have long opalescent glass scales which can be seen many feet away and permit precision reading without eye strain. The instruments are highly damped and the time required for taking readings is reduced to a minimum.

The new analyzer provides General Electric engineers with the most advanced tool for system analysis and on occasion it has been made available for use by utility operating companies so that their own engineers may study their individual problems.

Air Compressor Operating Cost

Itemized Comparison of Steam and Electric Drives for Summer Operation

By C. C. Hermann

IN MANY manufacturing plants the supplying of compressed air during the summer months becomes a problem in economics. Steam for heating is not required, the power plant is not equipped with condensers and the air compressors are steam driven. This brings about a relatively high air cost as compared with winter operation when the exhaust steam is used in heating the plant, making it possible to charge to heating the larger portion of boiler operation. The writer has been consulted on various occasions regarding such a condition and in some instances the solution was the installation of electric drives for the air compressors for summer operation. This, however, is not always the most economical solution of the problem as will be noted from the following analysis of the conditions found in a representative plant.

In this plant the maximum demand for compressed air varied from 500 to 1000 cu. ft. of air per minute. The pressure was 90 lb. per sq. in. The compressor available was a 1400 c.f.m. machine, steam driven, of the compound type, equipped with intercooler and aftercooler but not having an unloading governor as would be required on an electrically driven machine. During the winter months a very good heat balance was obtained on the plant due to the radiation installed using the exhaust steam. During the summer the exhaust steam was diverted to the atmospheric release and the equipment operated non-condensing. The boiler pressure was 150 lb. gage saturated steam. The boilers were banked during the idle hours of the summer season and naturally the evaporation factor was very low, figuring from banked boiler to banked boiler. In this case the evaporation was 4 lb. of water per pound of coal. Bituminous 1¼-in. washed screenings were used, costing $4.30 per ton delivered in the bin. The plant handling cost for coal was $0.10 per ton to the furnace. During the summer two men were employed in the plant, one an engineer at $150 per month and the other a boiler room attendant at $4.50 per day on an 8 hr. basis. The labor charge against the plant was therefore $262.50 per month. The maintenance material cost was averaged at $60.00 per month and the outside labor cost at $65.00 per month, making a total maintenance cost of $125.00 per month. Depreciation on the plant was carried on the books at $300.00 per month, interest at $150.00 per month and insurance at $30.00 per month.

The fuel cost was figured on the basis given above, viz. $4.40 per ton on the grate, 4 lb. evaporation factor and 114 lb. of steam per 1000 cu. ft. of air. The air consumption for a representative summer month was 7,500,000 cu. ft. so that the fuel cost was $470.25 for the month. To recapitulate the results we note the following:

Labor per month	$ 262.50
Fuel	470.25
Maintenance	125.00
Depreciation	300.00
Interest	150.00
Insurance	30.00
Total	$1337.75
Air produced per month	7,500,000 cu. ft.
Cost per 1000 cu. ft. of air	$0.1783

For winter operation this cost is approximately one-third of the above figure due to the steam charge against plant heating. There is also an improvement in compressor economy due to lower temperature of inlet air, lower humidity and the consequent bypassing of the after cooler.

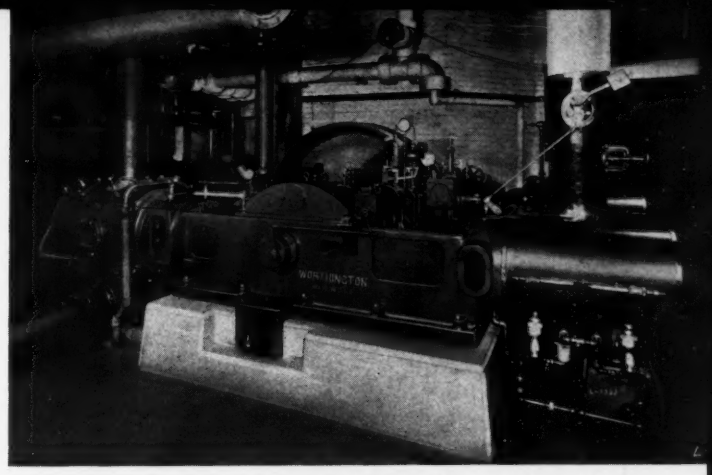
Since all electric energy for plant operation was purchased from the local utility company there appeared to be a saving possible by equipping the compressor with an electric drive permitting the closing down of the power plant. Examination of the electric energy contract disclosed a demand charge based on the four high 15-min. periods each month of $1.25 per kw. The energy charge was $0.02 per kw-hr. for the first 50,000, $0.015 for the next 200,000 and $0.01 for all over 250,000 kw-hr. A power factor penalty prevailed under 80 per cent power factor. The average plant power factor was 72 per cent so that here was another chance to make a slight improvement by installing a synchronous drive on the compressor. The compressor must be equipped with an unloading governor and the steam end must be disconnected. A belt drive must be provided between the flywheel and the motor pulley. The total investment would be approximately $2200.00, increasing the depreciation, interest and insurance figure for the plant another $24.00 per month.

The average load factor on the compressor was found to be 60 per cent which for an electric drive would be equal to approximately 400 cu. ft. of air per kw-hr. Since the plant load was such that any further electric consumption would result in an energy charge of $0.01 per kw-hr. the energy cost would be $0.025 per 1000 cu. ft. The demand charge would be increased $125.00 per month. The recapitulation of charges for the electric compressor would be as follows, one man, of course, being cut off the payroll.

Labor for month	$150.00
Maintenance	30.00
Depreciation on p'ant as per above	300.00
Depreciation on electric drive only	24.00
Interest	150.00
Insurance	30.00
Electric energy	187.50
Increase in demand charge	125.00
Total	$696.50
Air produced per month	7,500,000 cu. ft.
Cost per 1000 cu. ft. of air	$0.09286

The saving per month by converting to the electric drive appears to be $641.25 or sufficient to write off the investment in 3 yr. 6 mo., however, since the electric drive would be used only from May to September inclusive, a period of 5 months the actual time required to liquidate the investment would be 8 yr. 5 mo., a period considered by many to be too long for a justification of the investment.

Development of a straight line, balanced steam driven opposed piston air compressor meets need for an efficient flexible unit for general industrial service. Capacity range from 500 to 7000 c.f.m. for two stage air ends covered by six frame sizes



Typical installation photograph of a medium sized opposed steam driven compressor with a piston displacement of 1451 c.f.m.

Opposed Type Steam Driven Compressors

By E. M. PAULLIN

Consulting Engineers, Compressor Div.
Worthington Pump & Mach'y Corp.
Buffalo, New York

STEAM DRIVEN air compressors of the opposed piston type can hardly be classed as a new development, but the introduction of the Worthington opposed steam driven compressor made available, for the first time, a completely balanced and self-contained steam driven unit.

For many years the only steam driven compressors available were power-driven designs to which steam cylinders had been added. The length of the machine was simply extended and the steam cylinders placed between the compressor cylinders and frames. This gave rise to the common nomenclature and the machines are still known as the extended air compressors.

In order to provide for cylinder accessibility, distance pieces between the cylinders and the frames and between cylinders were added. While this helped in some measure, accessibility was still limited and the overall length considerably greater than actually necessary.

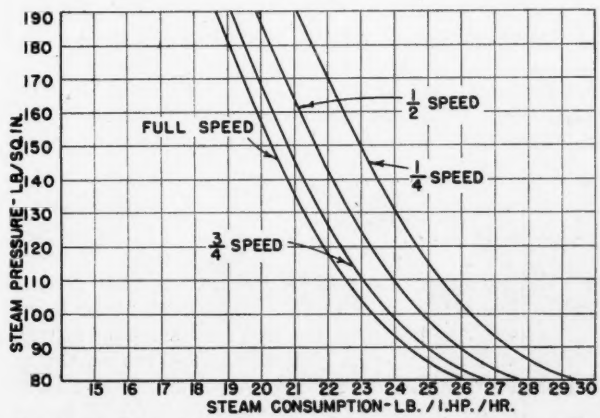


Fig. 1. Variation of steam consumption with pressure and speed for a 14 in. stroke duplex compressor with a cross compound steam end for atmospheric exhaust

After further study, compressor engineers conceived the idea of a double ended frame with the air cylinders on one end and the steam cylinders on the other end, giving equal accessibility to both steam and air cylinders. The first builder of this type of machine, however, visualized each end of the frame as the same and exceptionally long crank pins were used with double connecting rod construction and separate cross heads in each frame end. Steam and air cylinders could not be placed exactly in line and each frame was required to withstand unbalanced mechanical forces arising from the design itself.

Opposed Design

With the introduction of the Worthington opposed compressor a complete revamping of the frame structure, the elimination of one connecting rod and the use of an oiling system working under positive pressure initiated a new trend in the art of building steam driven air compressors. The double crossheads were tied together with stretcher rods and, by placing the piston rods exactly in line, the straight line power stroke with uniform frame loadings provided a machine which is inherently balanced.

These opposed type steam driven compressors are available with two-stage compressor ends in sizes ranging from approximately 500 to 7000 cu. ft. piston displacement. Any of these machines can be built for single stage operation using two air cylinders of the same size and omitting the intercooler which would ordinarily be used between stages. The entire range is covered by the use of six frame sizes, each size associated with a definite compressor stroke. Exact cylinder diameters are

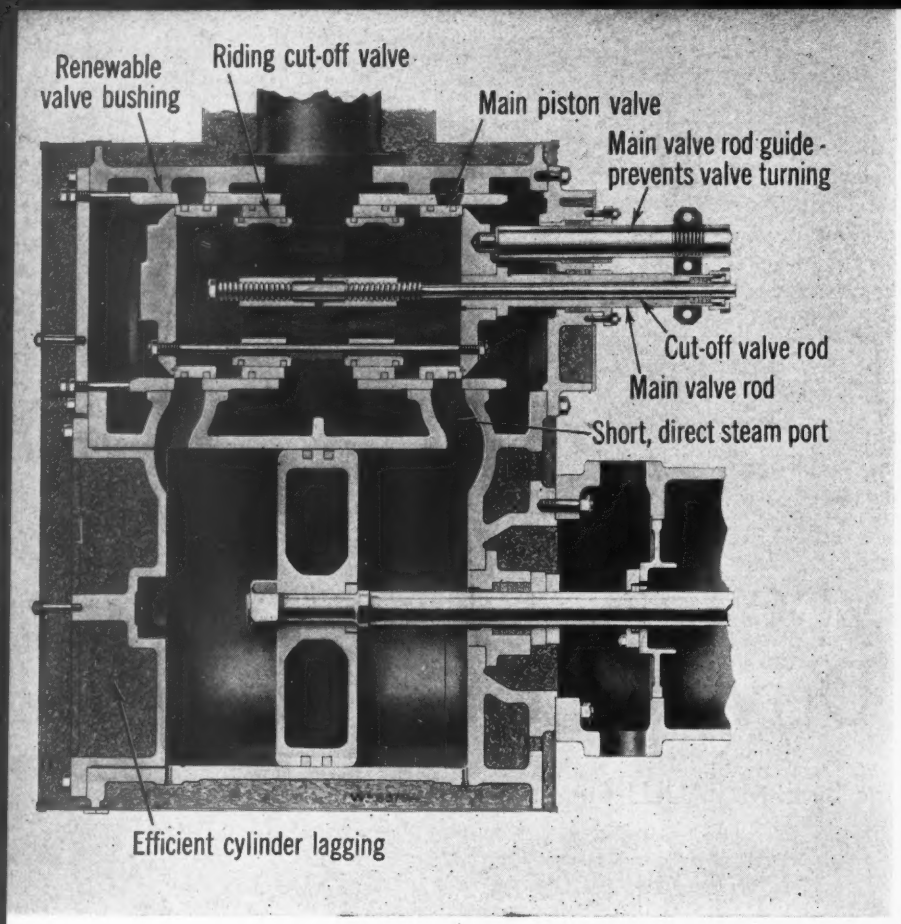


Fig. 2. Cross-section through the steam cylinder showing the arrangement of the riding cutoff double piston type steam valve

varied with pressure requirements so that the maximum horsepower may be taken out of each particular frame size.

Best operating economy is obtained with the higher terminal steam pressures utilizing a long expansion and naturally with the machine operating at or near its normal full load speed. As a rule, the larger the compressor the better the steam economy but high operating efficiency is not sacrificed in even the smallest size. Typical steam consumption curves for an average size compressor are shown in Fig. 1. The relationship between steam consumption and initial steam pressure is expressed on the basis of atmospheric exhaust and the curves show the normal increase which may be expected as the speed of the unit is reduced below normal operating speed.

Operating economy obtained is the result of provision for an early cutoff with consequently high steam expansion. The economy can also be attributed to the use of the Worthington balanced piston type of valve with adjustable riding cutoff. The exact point of cutoff can be controlled manually or by a governor.[1] With this arrangement the speed of the machine can be varied to meet the load demand on the compressor and, at the same time, the steam cylinder can be operated at the point of cutoff resulting in maximum efficiency.

Short direct steam ports result in negligible friction and condensation losses. Eccentrics, carried in dustproof housings and, operating from the main compressor shaft, control both valves. In the steam chest the steam is admitted through the center of the valve, thus avoiding contact with chilling surfaces until the steam expansion has taken place. The valve rod stuffing boxes are, therefore, subjected only to exhaust temperature and pressures and, by the use of carefully fitted snap rings, loss through steam leakage is negligible. Efficient cylinder lagging is also a factor in the maintenance of steam economy.

Steam cylinders may be arranged for simple engine operation, or they may be built as a cross compound engine. The selection of a simple engine or a cross compound engine is dependent first of all upon the initial steam pressure available and second upon the back pressure against which the engine will have to work. Steam temperatures and degrees of superheat normally encountered in the average installation offer no particular problem.

Running gear in the compressor consists of a crankshaft with two counterweighted crank pins placed at 90 degrees. The crankshaft is carried by two main bearings placed one in each compressor frame. These bearings are of the two part type, Babbitt lined, and provided with shims for normal wear adjustment. The connecting rods are of the solid end type with wedge adjustable bearings at the crank pin and also at the crosshead.

The main crosshead to which the steam piston rod is attached carries the entire load of the machine. This crosshead is fitted with parellel slippers which are also shim adjustable for normal wear and an auxiliary crosshead at the other end of the frame is tied rigidly to the main crosshead by a stretcher rod construction. The auxiliary crosshead to which the compressor piston rod is attached is subjected to no direct shock and simply acts as a guide or steadying piece. Forces which are developed in the steam cylinder are thus transmitted in a straight line from one piston rod to another by means of the stretcher rod connection.

Lubrication

The compressor running gear is closely alined with the pressure feed lubrication system. All bearing surfaces throughout the machine are lubricated with a steady flow of oil. From a reservoir at the bottom of the frame, oil is forced by a gear pump to the main bear-

Fig. 3. Counter weighted running gear. The two cranks are set 90 deg. apart and the main crosshead, on the steam end at the left, carries the entire load. The auxiliary cross head on the air end, tied to the main crosshead by stretcher rods, acts simply as a guide

[1]EDITOR'S NOTE. A second article by Mr. Paullin, dealing with steam valve setting and with the governor is now in the course of preparation and will appear in a later issue.

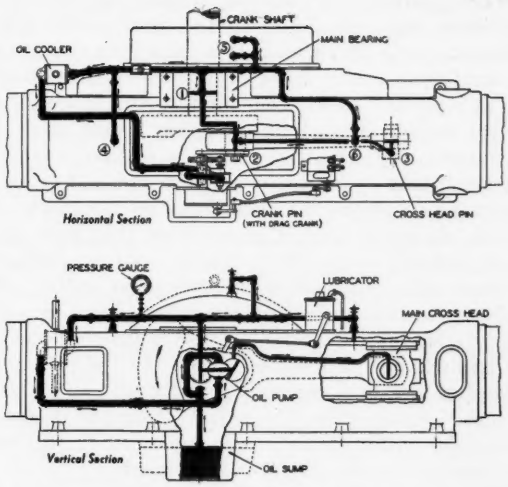


Fig. 4. Plan and elevation of the center section of the compressor showing the force feed lubrication system in black

ings. The main shaft is drilled through to the crank pin where oil, still under pressure, is forced to the crank pin bearings and through a pipe on the connecting rod to the crosshead pin bearing. A filter and a lubricating oil cooler in the line assures cool operating temperatures for all bearings. A pressure gage in a prominent position indicates the presence of oil pressure at all time. Each side of the compressor is lubricated independently of the other, that is, duplicate pumping equipment is provided in each frame for this purpose.

The air and steam cylinders as well as metallic packing glands are lubricated by a force feed lubricator mounted on the compressor frame and driven by a mechanical connection from the crosshead.

Cutoff in the steam cylinder is under the control of the governor at all times. The governor works directly from a flyball speed element which follows the compressor speed. If it is desired to operate the compressor at a lower speed, the spring setting in the flyball element is simply reset. This can be done manually or can be made responsive to pressure which will then indirectly control the steam cylinder cutoff.

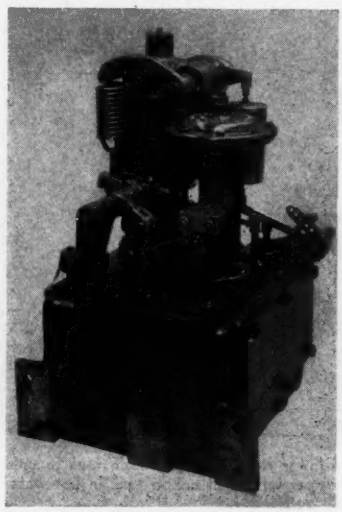


Fig. 5. The Class 30 automatic cutoff governor used with the opposed type compressor. It may be used to give either speed and pressure or variable speed governing

Positive and extremely sensitive action of the governor is obtained through the use of relay valves. In other words, the flyball element or the pressure element are required to operate only small pilot valves. These pilot valves in turn control relay valves hydraulically which do the actual work of resetting the flyball element speed-spring or the lengthening and shortening of the steam cutoff. The hydraulic transmission system receives its power from an oil pump contained in the governor case and driven with the flyball element from the compressor crankshaft. A study of the diagrammatic arrangement of this governor[1] will disclose its simplicity and dependability. In keeping with sound engineering practice a separate independent overspeed safety trip is provided on all units.

Incandescent Lamp Sales in 1937

A PRELIMINARY estimate indicates that more than a half billion large incandescent lamps were sold in the United States during 1937, according to a review of the electrical industry prepared by Guy Bartlett of the General Electric Company. A total of 955,000,000 is indicated for both large and miniature lamps—515,000,000 large and 440,000,000 miniature. Each of the totals is the highest yet attained.

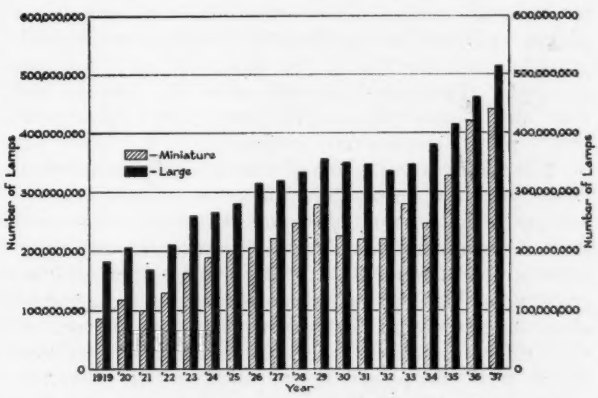


Chart showing annual sales of incandescent lamps, 1919 to 1937 inclusive

Among the new types of incandescent lamps are a 300-watt lamp with a high-efficiency coiled filament and single-contact prefocused base intended primarily for motion-picture projectors, and a new 300-watt lamp with a medium-screw base developed to fill the need for a lamp of this wattage with a short light-center-length for use in fixtures now using the 200-watt lamp.

A 100-watt mercury lamp and control mechanism for photographic work and a lamp designed for projection use with a microscope are outstanding developments in the field of special purpose lighting.

In the field of highway lighting an interesting installation is the lighting of the San Francisco Golden Gate Bridge with 214-10,000-lumen sodium-vapor luminaires. The units are approximately 150 ft. apart and are mounted at a height of about 25 ft. Another leading installation was made during the year at Detroit, where 31 mi. of street lighting was modernized with incandescent 10,000 or 15,000-lumen series lamps in Alzak aluminum reflectors designed to throw a large percentage of the light on the street.

Electrolytic Control Decreases Maintenance

Milk plant employs electrolytic method of preventing corrosion and scale formation

By C. HAMMOND,
Supervising Engineer

AXIOMATICALLY, the purpose of power plant maintenance is to provide a sustained supply of power at lowest overall cost. This simple proposition has many ramifications, particularly in steam power plants, where a number of variable factors beyond the engineer's direct control mitigate against the sustained efficiency of any set maintenance procedure.

Although maintenance procedure in steam power plants is, therefore, necessarily evolved to fit individual conditions, it can be generally said that the greatest common problems are those of corrosion and scale prevention. These are present in every steam power plant, varying only in degree.

The steam power plant of a large milk company, in Brooklyn, N. Y., presented a particularly difficult problem in scale control. Artesian water is being used from the company's own wells. For several years water was supplied from a 100-ft. well, which, although comparatively high in calcium content (and therefore abnormally scale-productive), nevertheless did not unduly affect maintenance costs. In July 1936, a new 120-ft. well was placed in operation, which proved to possess water so high in calcium that scale removal became a major item of expense.

In addition to clogging up the feed lines, the most severe difficulties were encountered in the heater unit installation. Two heater units, each with a 200-g.p.m. capacity, are available, operating alternately while the other is being serviced. Rapidly forming scale deposits —½ in. of scale in about four weeks—necessitated weekly turbining, and the extremely hard scale was expensive to remove. One of the heaters soon had to be re-tubed, at a cost of some seven hundred dollars for material and labor. As a corollary, the loss of heat transfer efficiency necessitated greater consumption of steam in the heaters, reflecting adversely on the overall operating costs of the power plant.

In an effort to find a solution, the Kirkaldy system of electrolytic metal protection was installed in April 1937. Six months continuous operation demonstrated that not only was scale formation and corrosion prevented, but old scale deposits and rust were eliminated. Preliminary cost figures show an estimate of 70 per cent saving in maintenance in addition to higher heat transfer, hence less coal requirements.

The apparatus is a recent application of well-known principles, engineered for control and prevention of corrosion, scale and slime. It is based on the electrochemical conception of corrosion phenomena; elimination of scale and slime is concurrent with its corrosion-control action. In the milk company's case, scale was the outstanding difficulty, corrosion was not abnormal, and slime was not a factor. The performance of the apparatus, therefore, is indicative of its versatility.

The electrochemical theory states that each metal has a tendency to go into solution in water, displacing an equivalent amount of hydrogen or metal. This tendency varies with different metals, and is called their "solution potential." These solution potentials can be arranged in a series, called the "electromotive series" of metals; compared to hydrogen (an arbitrary standard), the value is called "normal hydrogen potential." All other factors being constant, this value is a measure of corrodibility of the metal.

These factors, however, are never constant. The degree of corrosion varies with homogenity of the metal involved, its juxtaposition to other metals of different solution potentials, chemical content and temperature of the water, and other factors which serve to produce, in effect, a galvanic battery or, rather, an electroplating tank. The thin protective film of hydrogen which forms on the metal walls and prevents further corrosion combines with the oxygen dissolved in the water and is thus removed, constantly restarting the corrosion cycle.

Corrosion, therefore, may be regarded as a phenomenon inherent in metallic water containers, and the

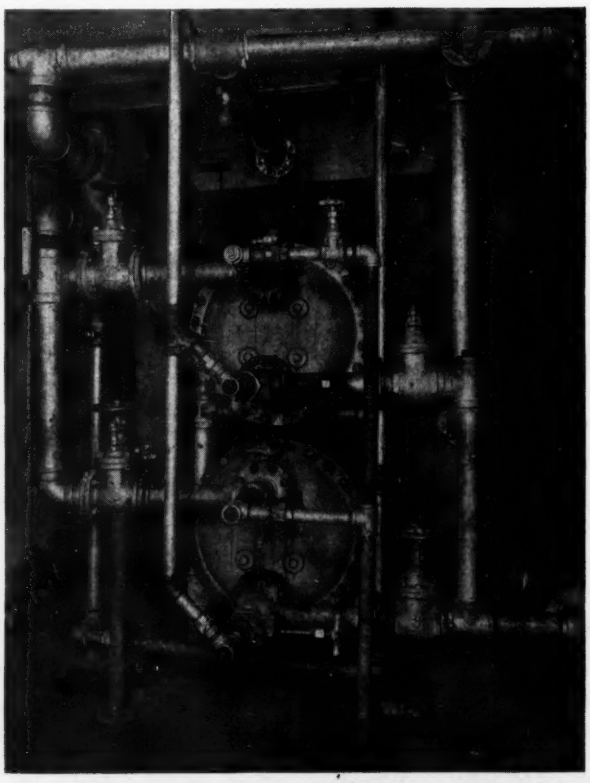


Fig. 1. Hot water heaters. At lower right is large anode tank in cold water inlet of the heaters; at upper left small anode tank in hot water outlet

conventional methods of corrosion prevention, such as painting the walls or plating them with a low solution potential metal, are at best palliatives; such methods, furthermore, cannot be employed in power plants.

The Kirkaldy system prevents corrosion by controlling it. Since a corrosion-affected vessel is an electroplating tank, with the corrosion taking place at the anodes, the Kirkaldy apparatus introduces into the water a special anode, intended to be corroded, and reverses the current. The metallic water container then becomes cathodic and corrosion-free. All corrosion phenomena are now confined to the anodes instead of the walls.

At the same time, the various acid radicals, such as sulphates and silica, necessary for the production of the scale, cannot adhere to the cathodic walls, and are electrically attracted to the anodes. Most of the electrically charged particles are harmlessly carried away with the discharged water; others lightly adhere to the walls in the form of a soft sand-like deposit, which forms but slowly and is easily removed by ordinary brushing, or with an air hose, or by backwashing. If allowed to dry or bake, the deposit does not become stone-hard as scale, but remains soft and fluffy and is removed with equal ease.

As a result, it was found advantageous, from the maintenance point of view, to install on the heaters a simple system of piping for backwashing alternately the heaters and the separate tanks containing the anodes. Drains were also provided in the bottoms of the anode-containing tanks, to aid in removing the residue. This method of cleaning ensures a quick and

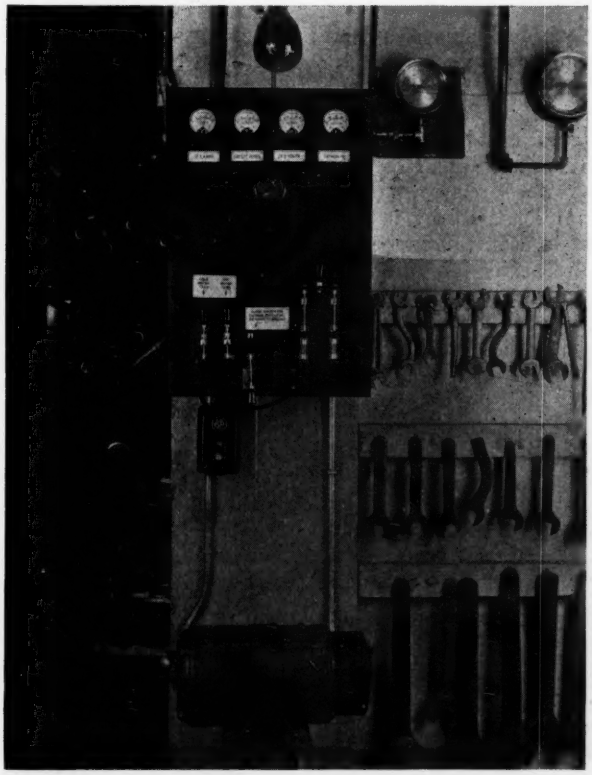


Fig. 2. Small motor-generator set and switchboard with instruments and switches for controlling the operation of the system

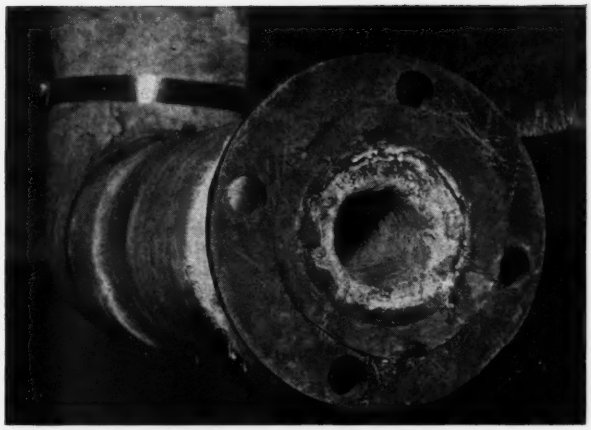


Fig. 3. Accumulation of hard scale before the electrolytic system was installed

thorough job. Turbining has become unnecessary, and the heater tubing is now automatically maintained scale and corrosion free.

The same phenomenon is claimed to occur with slime deposits; however, since slime trouble is not inherent in heater operation, no first-hand observations could be made.

The entire Kirkaldy system equipment consists of a number of suitably constructed anodes (carbon or mild steel), installed within the water but electrically insulated from the walls of the water circulating system; an electric motor-generator; a control switchboard; and the necessary wiring to complete the circuit, with the water acting as the electrolyte. The operating norms are established on the basis of the total anodic surface available, total container surface to be protected, and the chemical composition and operating temperature of the water. Once established, the operation is automatic and requires no further attention beyond an occasional readjustment of the current feed at the control switchboard to compensate for minor operating variations.

Current consumption is extremely small: 12.5 amp. at 12.5 v. was found ample to serve the abnormally exacting requirements of the case described. Ordinarily, it is understood that less than ½ kw-hr. per day is sufficient for the protection of 1000 sq. ft. of container area where salt water is used, and approximately 1 kw-hr. per day per 1000 sq. ft. if fresh water is used.

The installation presented still further aspects of more than passing interest. The construction of the heater units was such that it was impossible to install the anodes within their structure, as is the recommended practice of the manufacturers. Therefore, the anodes were placed in a separate tank through which the heater intake water must now flow. Naturally, the current potential drops with the distance from the tank; nevertheless, it was found adequate to maintain the entire heater installation sufficiently free from scale and corrosion to meet the most exacting maintenance requirements.

As an added precaution against unforeseen operating conditions, and to aid the intake tank in combating scale and corrosion at the discharge end, a smaller second tank was installed through which the heater discharge is now fed. The electrolytic action, of

course, takes place equally well with or against the water flow.

An additional benefit was derived from the installation, far beyond the confines of the heaters proper. The electrolytic action also attacked scale and corrosion in the entire piping system, which is not electrically insulated from the heater units and is, therefore now also rendered cathodic, though in a smaller degree. No further scale formation occurs in the pipes; in fact, the existing scale is gradually disappearing, despite a considerable distance from the anode-containing tanks.

As a check on the effectiveness of the protection, not only in the heaters but also throughout the pipe lines of the building, a section of the pipe five floors above the heaters was removed for inspection after the system had been in operation for eight months. The heavy scale that was usually building up in this pipe had now completely disappeared, and the pipe was found to be perfectly clean and no corrosion or pitting could be detected.

Investigation reveals that, although the underlying principles employed in the Kirkaldy system have been known for some 50 yr., their commercial application had to await research into the many variable factors which are involved in the corrosion phenomena. The first practical application dates to the World War, when many vessels in the British Navy were equipped with rather primitive devices for corrosion prevention, based on maintaining the reverse polarity of the metals requiring such protection. The principle is still being used in marine work, although the devices are greatly perfected and improved.

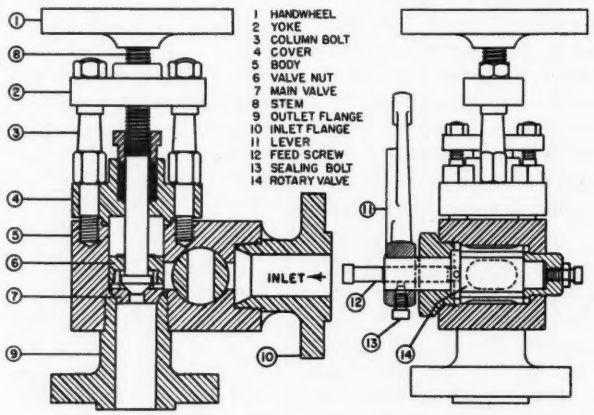
High Pressure Valve Design

By Frank Patterson*

HIGH BOILER pressures have brought new problems in valve design, pressures up to 600 lb. being common, 1250 to 1500 lb. frequent and 2500 lb. in contemplation. Economy from high pressures is well known but progress has been retarded by difficulties in design, and inability to procure standard valves and equipment suited for such pressures. Materials and construction must be adapted to the purpose, forged steel being suitable, but valves of that material not being obtainable in sizes larger than 2½ in. until recently.

Design of a blowoff valve for pressures up to 2500 lb. per sq. in. is an example of the problems which confront the designer. For such service, the valve must be strong, shock-proof, with two separate valve mechanisms in series, either to be repacked under pressure in closed position. The two should preferably be in a single unit, as intermediate flanges provide an extra hazard. There should be no internal pockets where scale might lodge, and opening and closing should provide for gradual building up and cutting down pressure. Wire drawing of discs and seats must also be considered, probably the best preventive being the use of Stellite, an alloy of cobalt, chromium and tungsten which has great hardness.

One recent design for such a valve provides a single forged steel block to house the separate valves with flanges only at the ends of that block. The inlet valve next the boiler is cylindrical, moving in a cylindrical seat with about 0.008 in. clearance; the cylinder has longitudinal grooves each side of the ports, these grooves being filled with semi-metallic packing that is fed to them from a head chamber and forced home through radial holes in the valve stem by means of a feed screw in the stem. Pressure on the packing can be relieved by backing off this feed screw so that operation at high pressure is easy, and the packing can be tightened after the valve is closed. Repacking in closed



Cross sections of high pressure blowoff valve

position is by backing out the feed screw and forcing in additional packing from a cylindrical repacking cylinder which screws into the feed screw opening. The cylinder has journals at each end, which keep it centered in the bore and carry the pressure when the valve is rotated.

The screw down or outlet unit, of the tandem blowoff valve, must provide means for draining the boiler, also it is used to reduce boiler water concentration. The first calls for fairly large size to empty the boiler quickly, the second for gradual discharge during blow down, requiring relatively small size, for frequent small quantities of water. The two requirements are conflicting and frequently a valve larger than required for blow down is installed, which results in wire drawing of discs and seats during blow down because the valve is only partly opened. Gradual opening and closing are especially important when flow of a solid column of water under high pressure is to be handled.

Solution of the problem has been found by placing a small auxiliary valve and seat within the main valve, first turning of the hand wheel opening the auxiliary valve and the main valve remaining closed until the auxiliary has been fully opened. This gives gradual opening and closing and experience shows that the main valve seldom leaves its seat, while the auxiliary is practically always wide open during blow down. As it is stellite faced, its life is long.

Where future pressures will go, is hard to predict but performances of plants at 1000 lb. or more indicate continued advance.

*In Charge of Engineering, Clees Valve & Engineering Co.

Readers' Conference

Power Factor Correction

TODAY MANY people shy away when they hear power factor mentioned, but, with proper knowledge and application, great improvements can be made in the average plant, especially where induction motors are the chief source of power. It has been my experience that if high efficiency and good power factor are to be attained, it is desirable to use 1800 r.p.m. motors whenever possible. If the machine speed is less, then a worm geared or spur geared motor could be employed. If the machine is a steady load and the maximum load determined the motor should be no larger than necessary. Units that stop and start frequently should be group driven if possible and if this cannot be done, then a capacitor should be used to build up the lagging current. In fact, it is good practice to equip any machine tool or machine that has variable loads with capacitors, as this helps the machine and protects the power lines from being overloaded by wattless current. Bare wiring, poor insulation and poor joints all take their toll in lost power. Every motor should have a periodic test to serve as a check on the condition and on proper loading as in many cases the selection of motors has not been overly well planned.

In plants where poor power factor exists it is sometimes possible to replace a quantity of small slow speed motors with single 1800 r.p.m. motors. This should be done where possible and in spots where the change would be impossible a capacitor bank may be employed.

Chicago, Ill. EDMUND E. HIGGINSON.

Gas Combustion Problems

IN POWER PLANT ENGINEERING for October 1937, J. R. Darnell stated in his rejoiner to a portion of the writer's article which appeared in the September issue, that he was amazed that Dr. H. H. Storch of the Bureau of Mines had expressed the opinion that a certain formula for determining the ultimate CO_2 of fuels was "entirely unsuitable for gases containing hydrogen or the hydrocarbons." The reply of Dr. Storch was given in full in the September issue. Nevertheless it was somewhat surprising that Mr. Darnall should brand the statement as "arbitrary" unless he were informed as to the nature of the inquiry.

The formula submitted to the Bureau for an opinion follows:

$$\text{Max. } CO_2 = \frac{20.9\ (CO_2 \text{ plus } CO)\ \text{(actual)}}{20.9 - O_2 \text{ plus } 0.4\ CO\ \text{(actual)}} \quad \text{(a)}$$

This formula differs from the one designated (4a) by Mr. Darnell in the October issue in that the percentage of O_2 in the air is taken as 20.9 instead of 21 per cent (it should be 20.7), and that the factor 0.4 was used instead of Mr. Darnell's later revision of 0.395 as the multiplier for the CO. It is believed, however, that these changes would not alter the purport of the equation.

The ultimate CO_2 of fuels may be considered the prime factor of all flue gas computations, and as a matter of course, due care should be exercised in determining it. The composition of the fuel burned affords the most satisfactory means of determining this factor. If inerts are present in a gas, and they often are, calculations based on hydrocarbon ratios or on Orsat tests could only be approximations. Similarly where a three pipette Orsat is used in testing and combustible constituents other than CO appears in the flue products, the ultimate CO_2 percentage arrived at may be inaccurate.

"There is another point to be noted here. Relatively recent research studies have shown that hydrogen may exist in considerable quantities in the flue gases in the presence of O_2 and CO." *It is obvious that formula (a) would be unsuitable should H_2 or any other combustible gases, except CO appear in the flue products. Checking an Orsat test which shows incomplete com-

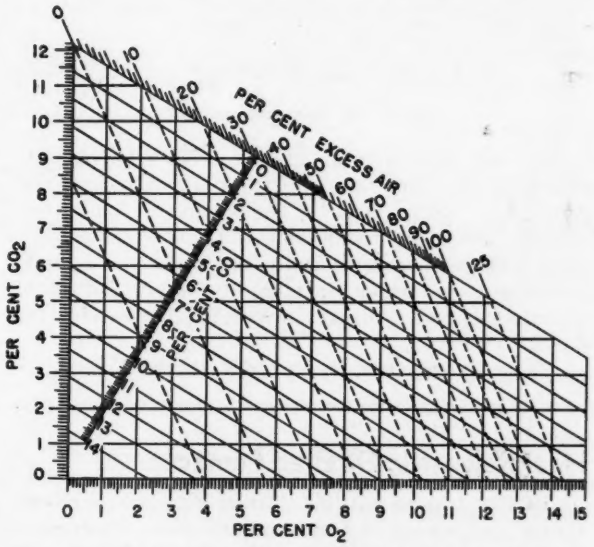


Fig. 1. Ostwald chart for checking Orsat analysis, drawn for Kettleman Hills natural gas

bustion with the ultimate CO_2 value has its advantages, but we fail to see the advantages to be gained by checking for the ultimate CO_2 value with such a test when samples showing complete combustion, or the correct calculated maximum CO_2 value are usually available. From a practical view point, it is believed that this formula will be found of little value, for as a rule, where natural gas is used as the fuel, no appreciable percentage of O_2 will be found in the flue gases when CO is present. "The presence of CO in the flue products tends to prevent the dissociation of CO_2 and unites with the oxygen, thus rendering the flame reducing."

It should be understood that this discussion applies only to gaseous fuels.

"The Ostwald chart shown in Fig. 1, is calculated

for Kettleman Hill gas, and affords a most convenient means of checking the Orsat graphically. Any point within the triangle represents simultaneous volumes of the three flue gas constituents, CO_2, O_2 and CO. If two are known the third is determined by the intersection of lines representing their values and no other quantity is possible. . . . Thus with accurate determination of the O_2 and CO_2, any unburned constituents will show up on the Ostwald chart. While the chart will show the presence of unburned, it will not necessarily be CO."*

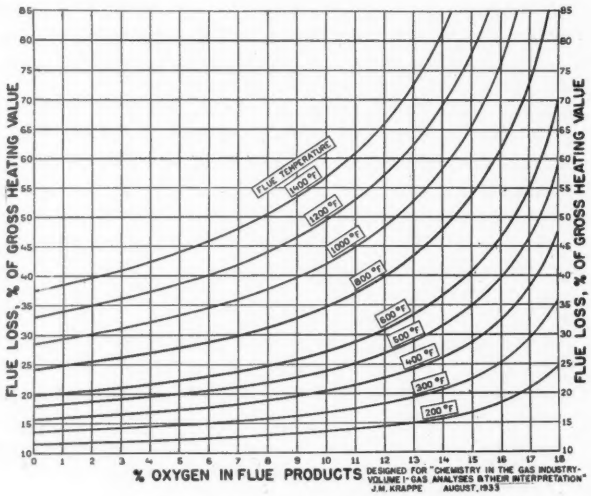


Fig. 2. Flue losses from gas fuel

We will close with an excerpt from a letter of C. George Segler, Engineer of Utilization, American Gas Association, New York. "The complete combustion analyses are easily predictable and follow the equilibrium equations mathematically, but when dealing with insufficient air, which, incidentally, ought not to be tolerated in boiler furnace practice, all equations fall down."

Sugar Grove, Ohio. HENRY COONEY.

*L. P. Stoker, Precision Instrument Co., in Gas, November, 1936.

Heat Release in Oil Fired Furnaces

IN THE ARTICLE entitled "Much Fire but no Smoke, Please" appearing in your January issue, reference is made to the allowable heat release per cubic foot of furnace volume.

In this connection, I think that it will be well to keep in mind the fact that the time may soon come, and indeed in some cases has already come, when the furnace designer will have little option in this matter.

There is a growing tendency on the part of cities and counties, to establish smoke control departments, having authority to enforce rules governing the design and operation of combustion equipment.

Hudson County in New Jersey has such a department, and Newark, N. J. and other cities are following suit.

There is no doubt that this is a step in the right direction, and it would appear that the only thing that is delaying the more rapid spread of public smoke control, is the cost of establishing bureaus and maintaining adequate organizations.

The Hudson County regulations allow for oil burning boilers, a release of 25,000 B.t.u. per cu. ft. of furnace volume and, as the efficiency of the boiler installation must be assumed, it is generally considered that 1½ cu. ft. of combustion space per boiler horsepower will meet this requirement.

Calculations are based upon actual developed horsepower, and not upon nominal horsepower. Before a permit for installation can be obtained, the proposed horsepower to be developed must be given, and anyone who creates smoke by forcing his boilers to an output in excess of that permitted by the furnace capacity, is likely to find himself in more or less serious trouble.

There is no doubt that such regulations have the approval not only of the public but of the better class of engineers, and where it is reasonably possible to do so, I think that it would be good practice on the part of designers to allow 1½ cu. ft. of furnace space per developed boiler horsepower, whether it is required by law or not.

Of course, in special cases it may be perfectly good engineering to figure on much higher heat releases, but with the general run of medium sized commercial boiler installations, about 1½ cu. ft. per boiler horsepower, would appear to be good conservative practice, if smoke is to be avoided.

Bloomfield, N. J. JAMES O. G. GIBBONS.

Safety Valve Vent Piping

VENTS, or escape pipes, must often be used with safety and relief valves so that any flow of steam or liquid will be discharged at a point where it will not endanger personnel, equipment, or building structures. If escape piping is necessary it should be designed so that back pressure will not interfere with proper operation and relieving capacity of the valve. Layout and supports must also be carefully arranged so that the weight of the piping and expansion and pressure reactions set up when the valve operates will not impose undue strain on the valve bodies and their inlet connections.

When designing escape piping the following rules taken in part from the A.S.M.E. Boiler Construction Code should be closely adhered to. These are:

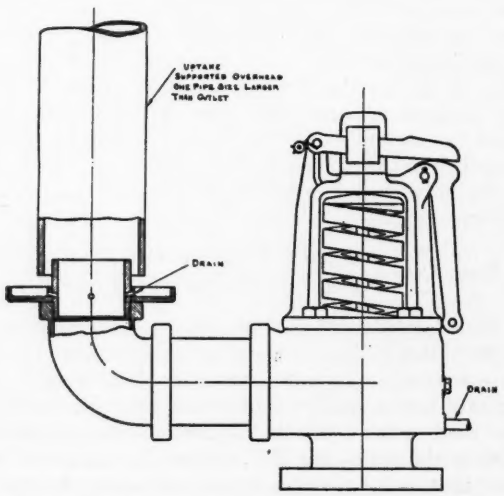


Fig. 1. Umbrella type connection for safety valve outlet

1. No valve of any description shall be placed in the escape pipe.

2. The cross sectional area of the escape pipe shall not be less than the full area of the valve discharge opening or the total area of all the valve discharge openings connected thereto. In general, if an escape pipe is very long it should be at least one pipe size larger than the above requirements.

3. The discharge piping should be as short and straight as possible. If numerous bends are necessary, these must be taken into consideration when determining the pipe size needed to prevent excessive friction loss with its resultant increase in back pressure.

4. Discharge openings should be carried clear of running boards and platforms. If carried through the roof

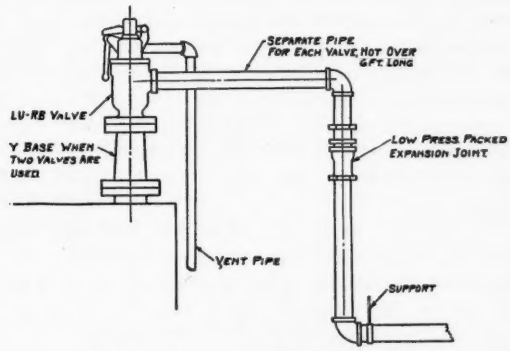

SEPARATE PIPE FOR EACH VALVE, NOT OVER 6 FT. LONG
LU-RB VALVE
Y BASE WHEN TWO VALVES ARE USED
LOW PRESS. PACKED EXPANSION JOINT
VENT PIPE
SUPPORT

Fig. 2. Outlet provided with expansion joint

the pipe should extend at least 6 ft. above the roof level to avoid injury to any person who might be in the vicinity when the valve blows. Lines passing through roofs should be equipped with suitable flashings to prevent leakage back into the building. Liquid relief valve discharges are usually piped to covered sewers, sumps, or in the case of high pressure hot water to blowoff tanks.

5. Gravity drainage shall be provided at all points where water may collect. If the line is exposed to the weather it should be arranged so that ice formations will not interfere with its discharge capacity.

6. If mufflers are used they should be designed so that back pressure is minimized and there is no danger of deposits restricting the steam passages. All points in a muffler where water might accumulate should be provided with open drains. When the vents from two valves are combined into a single escape pipe or where there is a long run to the discharge point, strains on the valves can be prevented by using flexible connections. The simple and inexpensive umbrella type construction, Fig. 1, is often used with boiler safety valves. If a tight seal is needed to prevent steam leaking into a room or in the case of discharge lines from relief valves of economizers or other vessels containing liquids, slip expansion joints, Fig. 2, are often necessary. In all cases the piping should be anchored in such a way that side or vertical thrust will not be transmitted to the valve.

Roanoke, Va. S. H. COLEMAN.

THE EDISON G-E APPLIANCE COMPANY recently installed an electric range in a home that had no electric lights. Now the owner of the home, an Alabama resident, eats his electrically cooked evening meals by the light of an oil lamp.

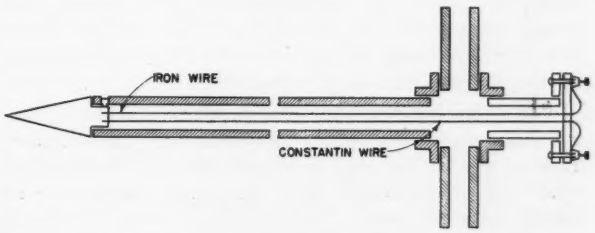
Fighting Spontaneous Combustion of Coal

SOME OPERATING engineers believe that when a fire starts in coal in storage, whether outdoors or in bunkers, the use of water is futile. Such opinion is not without justification. Of course, there have been occasions when fire in a coal pile was successfully extinguished with water, but in many cases it has caused a great deal of trouble.

If the coal is stored in a pit or bunker where the water cannot run off readily so that the burning coal can be submerged, naturally there will be no difficulty in extinguishing the fire. But where coal is stored out-of-doors in an open field the problem is often much more difficult. Once I was responsible for the fuel consumption in a large industrial plant where several thousand tons of Illinois and Indiana coal were in storage in an open field. When the rainy season started in the fall we had trouble with fires throughout the fall and winter.

Once we poured water on a fire with two streams from 4-in. fire hose for about 5 hr. At the end of this time the fire seemed to be out and we congratulated ourselves on having finally succeeded in overcoming the trouble with water, since many previous attempts had failed. But our jubilation was premature, for the next morning the pile was beginning to smoke again. After that we gave up attempts to use the fire hose and whenever a pile showed signs of heating we had the locomotive crane remove the heated portion and scatter it in an open space.

We found that it cost more for operating the fire pump and the men to man the fire hose lines than to move the coal with the locomotive crane. Besides, in freezing weather, frozen coal is difficult to handle and does not spread satisfactorily on stokers. The disadvantages of wetting the coal to put out a fire greatly outweigh the few advantages.



Thermocouple made from ½-in. pipe and fittings and provided with cone-shaped point is used to detect "hot spots" in coal piles

This leads to the question: What are the contributory factors in the spontaneous heating of stored coal? Authorities differ as to the probable effect of moisture, but my own observations have shown that if midwestern coals are put into storage piles during warm rainy weather the possibilities of spontaneous combustion are much greater than where the coal, if already dry, is stored during cool dry weather. Most authorities state that the sulphur content of coal contributes very little to spontaneous heating, but I believe there should be further investigation of this problem since there is a possibility that the form in which the sulphur occurs

in the coal may be either a positive or negative factor in spontaneous ignition.

For example, sulphur in coal may be found as pyrite (metallic sulphide), as sulphate, or possibly in some organic combustion such as various mercaptans, the simplest form of which is methyl sulphide. The presence of sulphides, either metallic or organic may cause more rapid oxidation than in coals where the sulphur is in the form of sulphates or in coal having little or no sulphur at all. But whether or not the presence of sulphur in some form is a contributory factor in spontaneous heating, it is significant that coals with high percentages of sulphur also have high percentages of oxygen. Most authorities agree that coals with high oxygen absorb oxygen readily and therefore have greater tendency to spontaneous combustion. Representative Illinois or Indiana coal may have 24 to 25 per cent oxygen as fired while Pocahontas or other Eastern coals will average 6 to 7 per cent oxygen. Accompanying the high oxygen in the mid-western coal may be 3 to 3½ per cent sulphur while the Eastern coal probably will have less than one per cent sulphur.

It is generally agreed that fine coal is more readily oxidized than coarse particles and therefore to avoid overheating and subsequent spontaneous ignition of the coal pile care should be taken to prevent segregation of the particles. This can be done if the coal is spread as it is dropped and not allowed to form cone shaped piles. But it is extremely difficult to get the average crane operator to spread coal in uniform layers and refrain from "peaking" the pile.

Some engineers have recommended the use of ventilating pipes in large coal piles, but this scheme has been largely unsuccessful since it is almost impossible to ventilate uniformly the pile in such a way that there is sufficient cooling to keep all of the coal particles below the kindling temperature. I have found by repeated measurements that if the coal temperature, generally found at 5 to 10 ft. beneath the surface, reaches 135 to 140 deg. F. this point should be kept under close observation and if the temperature rises rapidly above 170 deg., the coal should be moved from this point, spread out and cooled or immediately burned.

By using an especially designed thermocouple, connected to a potentiometer or galvanometer the temperature of a coal pile can be systematically checked and "hot spots" detected. Such a thermocouple can be easily made by peening thermocouple wires (iron and constantin or copper and constantin) into a cone-shaped plug which is fitted into one end of a piece of ½-in. pipe 12 to 15 ft. long. This cone-shaped plug is held in place by an Allen set-screw. Inside of the pipe the wires are threaded through glass or porcelain tubing or one of the wires may be wrapped with tape and connected to binding posts bolted through fiber disks, one of which is screwed on to a ½-in. pipe nipple connected to a cross tee just back of this. This cross tee is provided in order that short pieces of pipe, 8 to 10 in. long may be screwed into the sides of the cross for use as handles. These handles facilitate the insertion and removal of the thermocouple at various points in the coal pile. The accompanying figure shows a longitudinal cross section of this thermocouple.

Chicago, Ill. J. R. Darnell.

Dangerous Condition in School Plant

Last winter I was asked to go to a high school plant and find out why they were unable to heat the building.

I found two boilers of about 100 hp. each, one stoker fired and the other one hand fired. The janitor and a helper were baling coal into both furnaces, but seemed to be getting nowhere.

Looking around, I found the stoker full of clinkers, the air fan full of ashes and the fire bars burned badly. To begin with, the fire was cleaned, as was also the air duct, after which things looked better. One boiler was then shut down, and the load carried on the stoker fired boiler.

A general check-up was then made and a crack 1½ in. wide was found in the brick work, the full length of the boiler. A 3-in. ell in the return condensate line was cracked, allowing a lot of good hot water to run into the sewer. They had a duplex steam pump to deliver condensate back into the boiler. This pump, I know, had not been packed since the Spanish-American war and a lot of the hot water leaked out of here into the sewer, while cold city water was used to make up the boiler feedwater.

The following Saturday, when the plant was allowed to cool off, I had some men make repairs and clean out the stoker. While this work was going on, I removed some of the fire brick lining which had been placed against the fire box. When I started to give the fire box a hammer test, one light tap with the hammer convinced me that the shell was so badly rusted as to be dangerous. I was afraid to do any more hammering. The fire brick lining evidently was left in all summer, moisture formed, and ruined the fire box.

Surely somebody must make regular inspections of these places and their boilers, and why these conditions were overlooked is a question. I wonder how many more schools are in the condition I found this one.

Tomahawk, Wis. O. H. Heil.

Boiler Patches

Boiler Patches was an interesting article, but some of the statements might well be further qualified in order that a true picture might be presented to the reader.

It is admitted that horizontal return tubular boilers are patched with great frequency but patches are by no means confined to this type of boiler. On vertical tubular boilers it is often necessary to apply patches to the lower portion of the shell plate and also to the firebox sheets. The sheets of this type of boiler may become mud burned and thus become distorted. So, also, considerable corrosion and grooving may appear at the mud ring or ogee flange and require patching; and again, in the water tube boiler, grooving or corrosion (internally or externally) may necessitate a patch.

On the horizontal tubular boiler (flush type) the front head seam is protected by a brick arch and in many instances this arch will fall and the sheet will fire check or bulge, thus requiring a patch. Also, on this type of boiler failure to properly repair fire checks and leakage at the first girth seam will in many cases cause external corrosion which requires patching.

The patches shown in the article are designed for

the purpose of application to a boiler of cylindrical shape, where it is necessary to maintain the original pressure. In other words, on all boilers that are supported by staybolts, braces and tubes, it would not be necessary to employ these types of patches, for the reason that in the majority of code states patches may be used with certain limitations in all areas that are supported by staybolts or braces; that is, a patch can be used in a stayed area, provided the patch is held together by means of staybolts, so that the sheet would not be blown out of the boiler if welding should fail.

Since the majority of the States have accepted the A.S.M.E. Code, there are certain laws in these States governing the repairs on steam boilers. The safest procedure in the case of repairs is for the repairman to call upon an authorized inspector for instructions as to how the repair work should be done, and in this way the responsibility of making a correct repair is placed upon the inspector to whom it rightly belongs. The rules in the A.S.M.E. Code are merely suggestive and should not be used, as the only law governing the repair of a boiler is the one prevailing in the state where the boiler is located.

Regarding the sizes of patches that may be applied to a boiler, the weight of authority seems to agree that no calculation need be made regarding the pressure that a patch may be good for, when the patch is not more than 24 in. in length. Of course, it is necessary to use the correct kinds of materials, proper thickness, etc. When the length of a patch does exceed 24 in. longitudinally, then it is necessary to calculate the strength of the patch as shown in the article.

Buffalo, N. Y. JOHN J. TIMMONS.

Utilize Your Exhaust Steam

THE DECEMBER ISSUE contains a communication from W. F. Schaphorst on the utilization of exhaust steam. Of course, every engineer will agree in principle with his statements, but I cannot help feeling that Mr. Schaphorst places too much reliance upon appearances which are often misleading.

It is true that some plants are inexcusably wasteful in the use of steam, but in such cases no amount of talking about it is likely to make much of an impression upon those responsible; on the other hand, there are comparatively few plants which have any considerable amount of exhaust steam available which do not use as much of it as possible for heating the buildings in winter.

Mr. Schaphorst says that during the winter every bit of heat and every ounce of coal should be utilized "if possible." This is equally true at any other time of the year "if possible," provided it does not cost too much to do it.

Unfortunately, as a rule, not more than about 15 per cent of the steam produced by the boilers can be used in the form of exhaust steam for feedwater heating, which leaves 85 per cent, which may or may not be used elsewhere.

Those of us who have had experience in the utilization of waste heat have often been surprised at how little can be economically done in this direction.

It must be remembered that there is re-evaporation of high pressure drips and other unavoidable leaks which, especially in cold weather, make quite an impressive picture when the steam escapes to the atmosphere, but when the real amount of steam is figured, quite often it does not amount to nearly as much as appearances seem to indicate.

In dye houses, laundries and other plants, where live steam is used in the processes, there is often a great deal of vapor and re-evaporation, which gives the appearance of considerable waste. It is true that in some cases such as laundries, heat exchangers may be installed to take advantage of the heat in the waste water, etc., but every case presents an individual problem, and it does not necessarily follow that if it is decided not to make the investment to save waste heat, the decision is wrong.

It is true that exhaust steam can be used for refrigeration, provided you use an absorption or similar system, but comparatively few plants require refrigeration, and even if they do, an absorption system does not always figure out the best.

When it comes to selling our exhaust steam, we generally find ourselves facing all sorts of difficulties. The first one being of course to find a customer who is easily accessible. There is the matter of charges and metering, and then we find ourselves up against the same problem as the public utilities, which is that the customer expects to get service, if, as and when he wants it, which is not always if, as and when we want to give it.

Although there are many cases in which conditions could be considerably improved, I do not believe that things are nearly as bad as one might suppose by looking for steam leaks, out of a car window.

Bloomfield, N. J. JAMES O. G. GIBBONS.

Fuel Stored Over Long Periods

FOR VARIOUS reasons, it often becomes necessary for a firm to lay in a large supply of fuel in advance. Possibly the chief reason for doing this is to insure against a fuel shortage for their plant. It is not wise to go to excess in this matter, though admittedly there is only an occasional firm which does so. It should be remembered that there is more or less loss contingent upon excessive storage. Coal stored in open piles will deteriorate to some extent with the passage of time.

Doubtless in cases where it is considered necessary to have a long-time supply of fuel on hand, fuel oil should be given very careful consideration as against coal. It cannot be denied that there is less deterioration over long periods. In fact, if oil deteriorates at all in storage, it is to a very negligible degree. In certain cases and places, this advantage might easily be the deciding one, of sufficient importance to justify a change from coal to oil for fuel.

Peoria, Ill. JOHN E. HYLER.

Protecting Tools from Rusting

A SOLUTION for protecting tools from rusting can be made by dissolving some vaseline in gasoline. The tools are dipped in this mixture or it is painted on them. The gasoline soon evaporates, leaving a film of vaseline on the tools, which effectively prevents rusting. This mixture is very penetrating and gets into all joints.

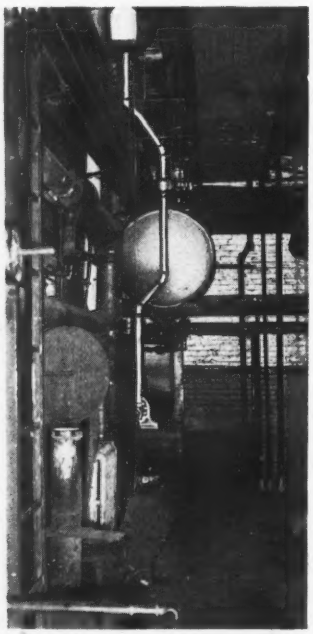
Sussex, England. W. E. WARNER.

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Boiler Water Clarifier

DEVELOPED to meet the demand for increased power plant efficiency and reduced fuel costs, the Clarifier is a simple, compact motor-driven unit manufactured by the Clarifier Corp. of America, 6025 West 66th Place, Chicago, Ill. It removes the mud and sludge from the boiler, without either continuous or periodic blowdown, and eliminates shutdowns for boiler cleanout. With this equipment the chemical treatment is accomplished at actual operation pressure and temperature.



Mud and sludge accumulates in the Clarifier chamber outside of the boiler from which it is discharged occasionally direct to the sewer. The control of soluble concentrations without blowdown, either continuous or periodic, is effected by circulating boiler water through the mass of sludge collected on the Clarifier bed. In operation, 40 per cent of the boiler water is clarified per hour.

Plastic Pipe Ends

DESIGNED to prevent dangerous grounds, Dilecto pipe ends are a molded laminated plastic product having high electrical insulating properties, good mechanical strength and are unaffected by water, steam or chemicals at commercially used temperatures. These ends are made either threaded to fit standard pipe and conduit thread or plain with three set screws for fastening, both types being available in standard sizes from ½ to 4 in.

Dilecto pipe ends are the product of the Continental-Diamond Fibre Co., Newark, Del.

Food Locker

MADE of steel throughout, the Knickerbocker Food Locker has a baked enamel finish. Standard colors include white doors and black frames with sides, back and shelves of gray. The sides are of perforated sheet metal, grooved for strength.

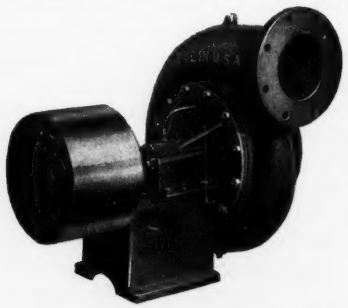
The front and back angles are welded into square frames on to which the shelves and sides are bolted. The lockers are shipped knocked down and are furnished with cadmium plated bolts. The shelves are of solid steel, 18 ga., with deep formed flanges. The doors are of the same material and have double flanges at the edges, as well as louvres for increasing air circulation. The number plates are of embossed brass.

Extra equipment that can be supplied when desired includes integral brass locks, with two keys and a master key. The bottom drawer can also be provided with rollers.

The lockers are finished in five standard sizes, the average of which measures 18 by 18 by 30 in. for each compartment. They are built in stands with as many compartments high as needed. Frick Co., Waynesboro, Pa.

Centrifugal Pump

TO MEET the demand for modern, low priced, centrifugal pumps, to give satisfactory, trouble-free performance under the most exacting conditions, Goulds has developed a new line of single stage ball bearing centrifugal units. Aside from performance,



simplicity of construction and design are outstanding features. They are relatively light weight and compact and, due to their adaptability to modern production methods in manufacture, permit unusually low prices when quality and ratings are considered.

Eighteen sizes of this new line give a capacity range of from 5 to 1600 g.p.m. against heads up to 110 ft. All sizes are equally well adapted for flat belt, V-belt or motor drive. Goulds Pumps, Inc., Seneca Falls, N. Y.

Adjustable Sheaves

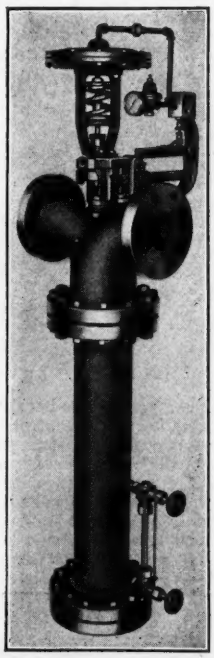
TWO GROOVE adjustable pitch diameter, texsteel sheaves for a speed variation up to 33 per cent on any driven unit, are announced by Allis-Chalmers Mfg. Co., Mil-

waukee, Wis. This type of sheave provides a sturdy, easily adjusted, variable speed drive for applications where the required load does not exceed 3 hp.

Pitch diameters on these sheaves are changed by stopping the motor, relieving the belt tension, releasing the Allen head locking screw and turning the adjustable plate in or out to the desired pitch diameter. These sheaves have been newly designed and carry many improvements in construction. The stationary part of the hub is cast integrally around the steel plates so that no amount of hard usage or abuse can loosen them. The movable portion of the hub is similarly constructed with sufficient material to form an external brace on the outside plate, thus assuring a smooth, true-running sheave at all times.

Copes New Desuperheater

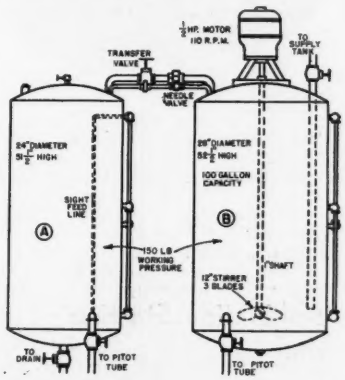
DESIGNED for either total or partial elimination of the superheat from steam to be used for process work, or for auxiliaries built for reduced-temperature steam, the new Copes Desuperheater has just been introduced by the Northern Equipment Co., Erie, Pa. It operates on steam from 212 to 1100 deg. F., maintaining within close limits the desuperheated steam temperatures regardless of changes in temperature of the superheated steam.



It is installed in the steam line as a self-contained unit. The only connections needed are a water supply for desuperheating, a water or air pressure line for the diaphragm operator, and a drain to carry off excess condensate brought over by the steam when the desuperheater is first cut into service. The flow of cooling water is controlled at the spray nozzle. A constant pressure drop is maintained across the nozzle, permitting a continuous supply of cooling water to be sprayed into the desuperheated steam in exact proportion to the demands, from minimum to maximum flows. Boiler feedwater can be used as a cooling water supply. Air or water can be used to actuate the pilot operator of the water control valve. Simple external adjustments permit varving the degree of desuperheat and the sensitivity of control at will.

Chemical Proportioner

DEVELOPMENT of a new type of proportioning machine employing the Haering fluid piston principle for the proportioning of mixtures of suspended matter has been announced by D. W. Haering & Co., Inc., 3408 Monroe St., Chicago, Ill. This new unit provides the accuracy of the H-O-H Feeders for the proportioning of lime and similar suspended chemicals. The Model "S" Feeder is equipped with an agitator installed in the reagent compartment which is so designed and installed as to permit the continuous agitation of the reagent without danger of emulsifying the oil. Heavy suspensions of lime and similar chemicals can be carried in suspension and proportioned accurately through this unit.



This unit is constructed similar to the standard Model "B" Feeder except that sight feed indication is provided on the oil compartment in order to keep the reagent tank clear for agitation. Sight feed is indicated by water dropping through the oil.

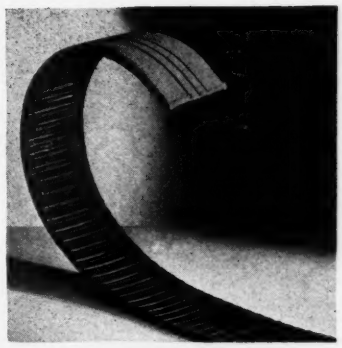
Model "S" unit operates as follows: Compartment A is filled with red oil and compartment B with the chemical solution. The machine is direct connected to pitot tubes and these valves are opened to place the machine in operation. The agitator is started from a control switch and kept operating all of the time the unit is feeding.

Water rises in compartment A into the upper gage fitting, and drops through the oil displacing the oil across a needle valve control and into compartment B where it, in turn, displaces the chemical suspension into the line. If desired, the discharge from compartment B may be piped into a tank, reaction chamber or softener instead of into the water line.

As oil enters tank B, it floats on the surface of the suspension while gradually displacing it and at no time passes through the reagent. The capacity of tank A is considerably less than tank B in order to prevent the oil level in tank B ever reaching the high velocity area of agitation.

Chrome-tex Belting

INTRODUCTION for commercial use of a new soft leather belting, fabric-backed, with a cross tread designed to increase pulling power, has been announced by the Sudbury Laboratory, South Sudbury, Mass. The cross tread is provided to permit the escape of air from between the pulley and the belt. The softness of the leather permits a squegee action, which further improves pulling power.

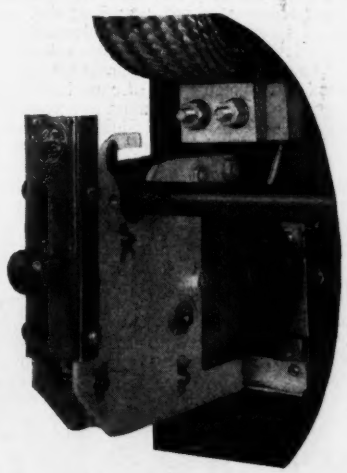


Use of the soft leather in the belting is made possible by the strong backing of specially woven and impregnated fabric. The face of the belt is made of an imported chrome leather. Since its cost, when new, would be prohibitive for belting, the Sudbury Laboratory uses leather reclaimed from industrial purposes which, by taking the stretch out of the leather, actually improves its quality as belting.

The fabric gives chrome-tex belting great uniformity and smooth running qualities.

Thermal Tripping Element

A NEW THERMAL tripping element for motor-starting application has been developed by the General Electric Co. for use with Type AE-1 industrial air circuit breakers. The new unit consists of a magnetically operated tripping mechanism which is restrained from tripping on overcurrent by means of a bimetallic element having thermal characteristics suitable for

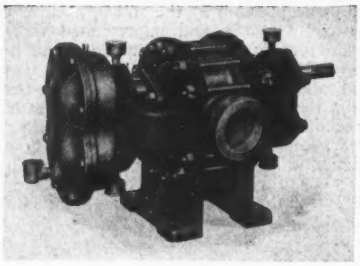


the starting and running protection of a.c. motors. This bimetallic unit, heated inductively from the magnetic circuit of the overcurrent tripping device, releases the armature of this device when the proper tripping temperature is reached. Means of calibration of the mechanism have been provided to raise or lower the tripping point as desired.

On overcurrents exceeding 10 times normal, the pull of the magnetic element acts independently of the thermal restraint, and instantaneous tripping occurs.

Rotary Pumps For Viscous Chemicals

A COMPLETE line of specially designed rotary pumps is now built by the Worthington Pump and Machinery Corp., Harrison, N. J., for viscous chemicals. They are ruggedly constructed to efficiently transfer such chemicals as: sulphonated oils, fatty acids, tallows, tars, asphalts, glues, gelatins, glycerine, petrolatum, residuum, hot bottoms, mineral oils, greases, animal and vegetable oils, molasses, sugar syrups, glucose, cellulose acetates and nitrates, viscose, rayons, cellophane and various film dopes.



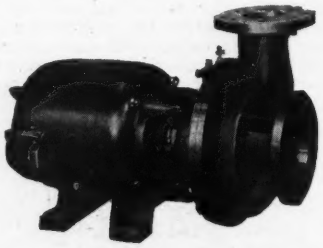
These pumps are available in iron, bronze, Monel, nickel, Everdur, stainless steel, aluminum, etc., for capacities up to 700 g.p.m., pressures up to 150 lb. per sq. in., and viscosities up to 500,000 SSU or 110,000 centipoises.

Motor Mount Pumps

SIMPLICITY of design, compact construction, high efficiency and moderate cost are among noteworthy advantages of this new line of pumps made for a wide scope of industrial requirements. Wide selectivity for size and capacity is provided by 63 units comprising a range of capacities from 5 to 650 g.p.m. The 63 units are available with three-phase motor. Single phase motor is furnished for 52 units of the line.

The impeller is the semi-enclosed, three vane type with non-overload power feature. It is adustable for capacity, head, clearance and wear. The one-piece oversize shaft is protected against abrasion. Integral construction of the impeller and shaft-protecting sleeve prevents any liquid from contacting the motor-pump shaft.

A two-piece, split type, bronze gland permits easy access to the stuffing box which has a water and grease seal on the 4302 Series and an adjustable water seal (which can be readily changed to grease or fresh water seal) on the 4312 and 4322 Series. Motor is the drip-proof type with moisture repellent insulation, deep-groove, over-size ball bearings and fan ventilation.



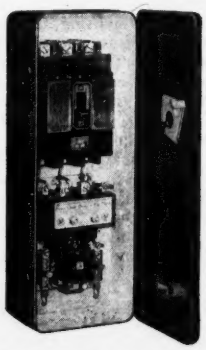
Exterior and sectional views, specifications, selection charts for various capacities and heads and other helpful details are contained in a new Bulletin 4300 available without charge from the manufacturer. Motor Mount Pumps are made by The Deming Co., Salem, Ohio.

Combination Starting Switch

A NEW combination starter utilizing circuit breakers has been recently developed by the Allen-Bradley Co., 1311 South First St., Milwaukee, Wis. The conventional type combination starter consists of a hand-operated disconnect switch and an automatic starter. In this new unit, the standard disconnect switch has been replaced by circuit breakers. These units have a maximum rating of 30 hp., 220 v.; 50 hp., 440-550 v.

The automatic starting switch is of the solenoid type, with double break, silver alloy contacts and two thermal overload relays. The circuit breaker is enclosed in a molded bakelite case and has three poles operated by a single lever. It can be tripped open or closed in the same manner as an ordinary disconnect switch. However, an overload in any pole trips a bi-metal thermal unit and opens the breaker. All poles are also equipped with an instantaneous magnetic trip.

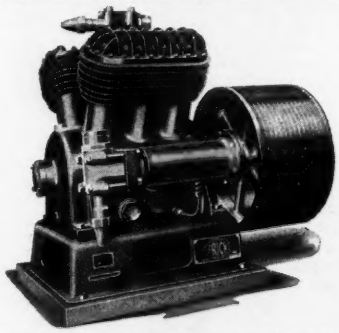
Reliable, accurate protection against sustained overloads is afforded by the resisto-



therm relays on the automatic starter. Short circuit protection is provided by the bi-metal and magnetic trips on the circuit breaker.

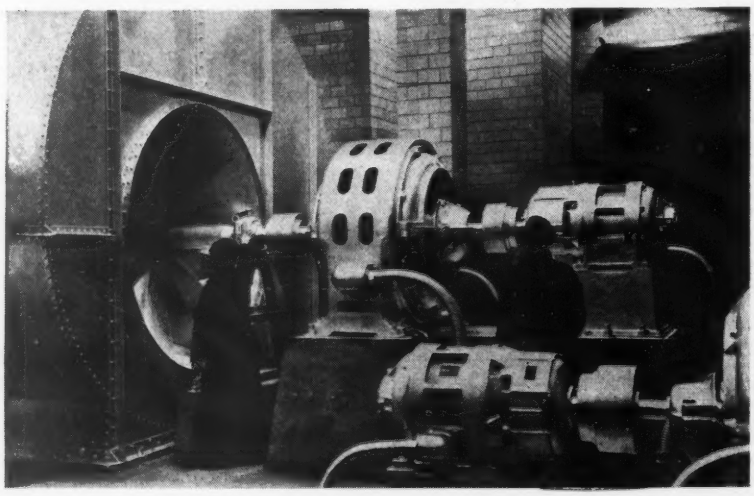
Low Pressure Refrigerating Unit

INTENDED PRIMARILY for air conditioning applications and using either Freon or methyl chloride, a new line of low pressure units has been announced by Frick Co., Waynesboro, Pa. These are built both



as separate compressors and arranged with condensers, motors and controls to form a complete refrigerating unit, the parts being mounted on a base of heavy steel channels.

The compressors with cylinder dimensions of 4¼ by 4¼ in. are built with either 3, 4, or 6 cylinders. The two latter sizes

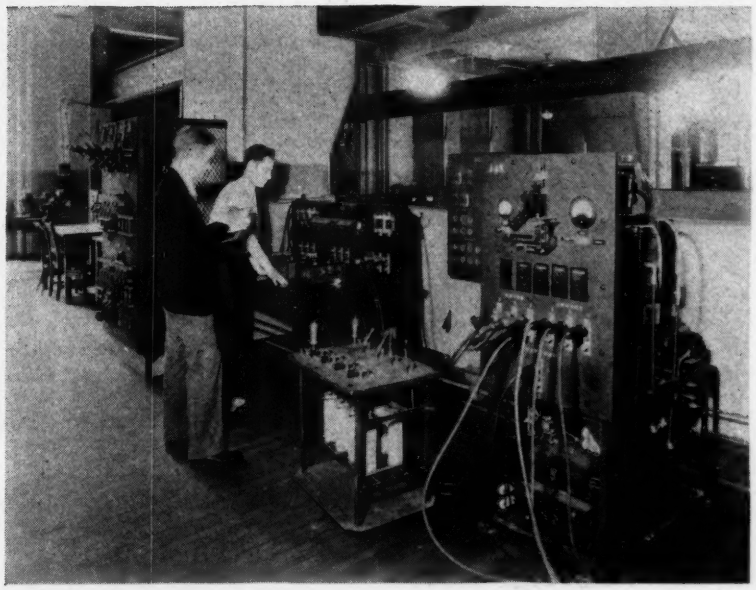


Ventilation in the Lincoln Tunnel

ON DECEMBER 21, 1937, the Lincoln Tunnel, connecting Uptown New York with New Jersey, was officially dedicated and opened to vehicular traffic. A parade through the tunnel consisting of army tanks, fire apparatus and 100 Fifth Avenue busses to carry the guests, completely filled the entire 8000-ft. tube. Thirty-six large double width Buffalo fans, handling about 3,500,000 cu. ft. of air per minute readily took care of the motor exhaust fumes and no haze in the atmosphere was noticed.

Mercury Arc Power Tubes in College Laboratory

BUILT ON the same principles as large steel-tank rectifiers and inverters, laboratory model-metal tank mercury arc power tubes provide students in college and university laboratories with a means of studying the design and operation of this important class of equipment in the electronic field. In the accompanying photograph is shown a small Allis-Chalmers air cooled metal tank rectifier installed in one of the laboratories of Massachusetts Institute of Technology.

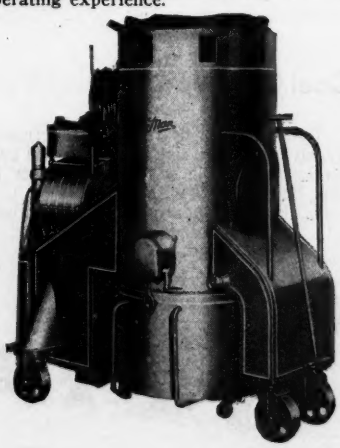


are arranged in a V-type. On air conditioning work, for which these machines are chiefly intended, they are charged with Freon-12, and when turning at 514 r.p.m. are capable of delivering 5 t. of refrigeration for each cylinder. They also deliver a ton of refrigeration for each horsepower expended in the motor. The 3-cylinder machine thus produces 15 t. and is driven by a 15-hp. motor; the others are in proportion.

On the side of each compressor is a suction scale trap arranged with an oil drain to the crank case. The suction and discharge valves are of multiple ring plate type, giving unusually large gas openings. The units have condensers with from 3 to 6 copper water pipes inside a large copper tube, and are arranged to use the highly efficient counter-flow principle.

Super-Duty Portable Vacuum Cleaning Unit

U. S. HOFFMAN MACHINERY CORP., Air Appliance Div., 105 Fourth Ave., New York, N. Y., announces that it is now placing in production a new type portable vacuum cleaning unit. The machine, according to the manufacturer, represents 2 yr. of research, design, testing and actual operating experience.



This new unit is a completely equipped, super duty cleaner designed to remove large quantities of accumulated dust with economy. This portable cleaner is capable of many hours of continuous operation on heavy deposits of dust before it is necessary to stop work and empty the container. It has a dust collector equipped with a raising and lowering device actuated by a crank handle with 3½ to 4 times the dust storage capacity of the average portable cleaner. Another innovation is the provision of carrying space on the unit for the hose and all of the cleaning tools and accessories.

Burgess New Industrial Mufflers

TO SILENCE the exhaust noises of Diesel and other internal combustion engines, as well as blowers and compressors, Burgess Battery Co., Acoustic Division, 111 West Monroe St., Chicago, Ill., has developed the new Burgess RMF Series Mufflers. These mufflers are designed for use in the most critical installations where ordinary mufflers do not provide adequate silencing—in hospitals, hotels, apartment and office buildings, and in power stations located in residential districts.

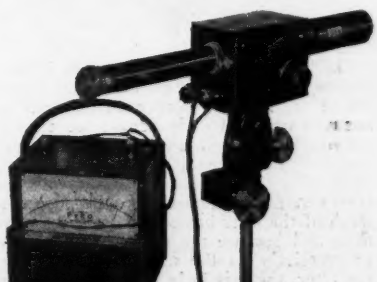
RMF Series Mufflers have been built with at least 60 per cent more silencing volume than standard heavy-duty Burgess mufflers to assure extra quiet. The low and intermediate pitched exhaust noises are suppressed in reactance chambers. The high pitched exhaust noises, which are ordinarily the most difficult to suppress, are absorbed by the patented Burgess acoustic lining. This lining consists of a perforated metal tubing, backed by an efficient heat-resisting sound absorbing material.

The patented Burgess acoustic lining permits a straight-through construction. There are no baffles in the path of the exhaust gases to restrict their flow, increase back pressure, and lower engine efficiency.

To withstand the corrosive action of high temperature gases, RMF Series Mufflers are constructed of extra heavy gauge sheet steel. Drain holes are provided at both ends of the muffler for the removal of condensation, oil, and sludge. Hand holes facilitate inspection and removal of the sound absorbing pads for cleaning.

Micro-Optical Pyrometer

THIS NEW Pyro Micro-Optical Pyrometer is designed for measuring temperatures of small objects such as incandescent lamp elements and for laboratory and other research work, and gives a 20-fold magnification by means of an optical ar-



rangement of high candle power. It is furnished and always used with a rigid support and tripod, the instrument holder being equipped with precision worm gear arrangement for accurate adjustment to focus the instrument on any given spot. The Pyrometer Instrument Co., New York City.

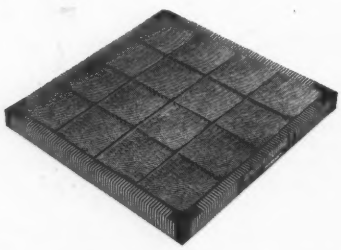
NEW BALL-BEARING BELT IDLER for moderate loads is announced by the Jeffrey Manufacturing Co., Columbus, Ohio, of 3-pulley, 20-deg. troughing type, for 14 to 36-in. belts. Pulleys are 4-in. diameter with shafts of ⅝-in. seamless tubing which may be lubricated from either end through pressure fittings.

Air Filters in the Oil Fields

Experience of large users of internal combustion engines shows that clean air effectively reduces engine maintenance. This photograph taken in the Fitts Plant of the Carter Oil Co. at Ada, Okla., shows a battery of Air Maze Corp., oil bath type filters used with Cooper-Bessemer, Type 10 gas engine driven compressor units. Ordinarily these filters would be placed outside of the building. In this case the engineers wished to have the filters inside the building and devised special hoods for the filters with the intake pipe extending through the roof. This is one of, if not the largest strictly gasoline plant in the mid-continent field. There are 38 of the 230 hp. Type 10 units with 17 by 20 in. power cylinders. Compressor cylinders are low stage absorption and two-stage residue machines.

Long Life Air Filter

A NEW throw-away type air filter for warm air furnaces, ventilating and air conditioning systems, air compressors, and internal combustion engines has just been developed by the C. F. Burgess Laboratories, Inc., 111 W. Monroe St., Chicago, Ill.

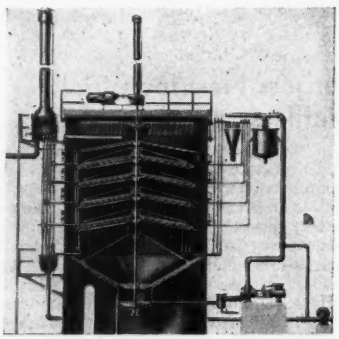


In this filter, air is cleaned as it impinges against layers of expanded fiber. These layers have been sprayed with a sticky compound that retains dust and pollen. Three sections—a coarse, medium, and fine mesh—make up the completed filter. Each section consists of seven layers of the expanded fiber. Because the mesh of the filter baffles gets progressively finer and because the stickiness increases progressively as the air travels through the filter, there is little danger of surface clogging, and dust is deposited uniformly throughout the entire filter. This, and the large surface area of the Burgess filter, assures a high dust holding capacity. Tests indicate that the filter will hold 132 grams of standard dust for every square foot of frontal area.

Water Clarifier

SEIP MULTI-TRAY CLARIFIER is designed and built on the principle of upward sludge filtration by means of periphery intake channels. It consists of one, two or as many as seven (depending on the size of the tank and the capacity required) round, inverted trays, supported by brackets attached to inner side of tank shell. The space within each tray forms a settling chamber and if the solution to be clarified is thick and has solids in suspension, these solids collect on the top of each tray (which acts as a bottom for the settling chamber above it) and function as an entangling medium for lightweight particles which would not otherwise quickly settle. This produces a clearer liquid.

Immediately above each tray there is a set of movable scrapers to carry away the surplus sludge. These scrapers are



operated from a central shaft, the speed of which can be changed to suit specific gravity of sludge encountered and the depth of sludge desired. In the top of each chamber is a liquid draw-off, located near the central shaft and as far as possible from the intake pipes, to allow longer time for settling and the production of a clearer, cleaner liquid. The Seip Clarifier, built for hot or cold liquids, is furnished complete with vertical tank and fittings, or can be accommodated to any existing tank. The Graver Tank & Mfg. Co., Inc., East Chicago, Ind.

Unibestos Heat Insulation

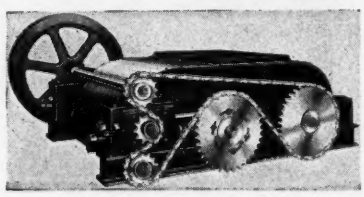
THE UNION ASBESTOS and Rubber Co., Cicero, Ill., has put on the market its Unibestos Heat Insulations, offering new high insulating efficiency with great structural strength and light weight, under all conditions of vibration, heat and moisture. Unibestos has a highly cellular, fibrous structure which is especially adaptable for heat insulation, providing a covering that is thermally efficient, yet strong and durable, and light in weight.

Unibestos Insulation is made in sectional form up to and including 24-in. pipe, which

is a new development in this field. It is easy to apply, even in the large sectional sizes, thus reducing labor costs. The products have been proven in actual service, and are used in prominent industrial plants over the country, and in the cruiser and destroyer program of the United States Government. Unibestos is furnished in sections for all pipe sizes, and in blocks for all insulating requirements.

Coal Crusher

TWO-ROLL, spring-relief coal crusher, known as Chain Drive Type "C", has been developed and placed on the market by Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill. The standard sizes include crush-



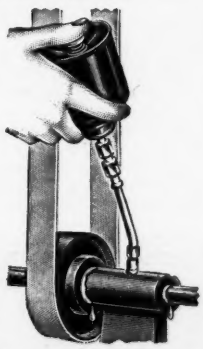
ers with rolls of 26, 30 and 36 in. diameter. This crusher is of compact design with all-welded steel framework and adjustment for any size of product.

Cut-tooth wheels and Silverlink roller chain form the driving connection to both rolls, from the crusher countershaft which is mounted in anti-friction bearings. Adjusting sleeves are provided with relief springs to protect against excessive stresses, any shock from these springs being transmitted directly to the welded frame.

Rolls are of segmental type, having cast iron spiders to which are bolted heavy, removable, alloy iron segments, heat treated to a Brinell hardness of from 500 to 600.

New Pressure Lubricator

ON BEARINGS, gears and other moving parts of machinery where oil is needed, the Acco-Morrow pressure lubricator, recently announced by the American Chain & Cable Co., Inc., solves a perplexing and costly industrial problem by supplying lubrication at pressure up to 1000 lb. Such pressure lubrication flushes out grit and dirt from a machine and at the same time forces oil into bearings.



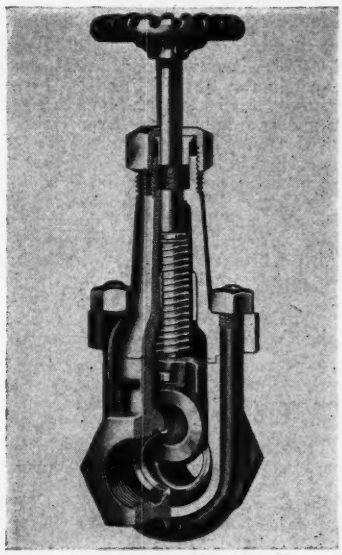
The Oilingseal tip, made of compressible composition is one of the outstanding Acco-Morrow pressure lubricator features. This tip makes a pressure-tight contact on the top edge of any common oil hole and practically all sizes and types of cups and oil hole covers in general use. No special fittings are needed.

Operating directions are to put the 'Oilingseal' tip into the oil-hole; make firm contact, then push plunger slowly. All active parts are made of brass or steel, and machined to accuracy.

The American Chain & Cable Co., Inc., of York, Pennsylvania, announce four gun-type Acco-Morrow pressure lubricators supplying pressure over 1000 lb. and six other type models supplying pressure over 500 lb. are now being manufactured.

U-Bolt Gate Valves

FAIRBANKS Improved U-Bolt Gate Valves, made with an iron body, bronze mounted, and in all iron, are designed to meet the demand for extremely rugged valves at a low cost. They are especially adapted for the exacting service in the chemical, paper, gas and petroleum industries, as well as for ordinary steam, water and air lines. Simple in design, with but a few parts, they can be taken apart,



inspected and cleaned with a minimum of effort and time. They are made in sizes from 1½ to 4 in. and have a 150 lb. steam working pressure and 225 lb. gas and liquid pressure. The Fairbanks Co., New York, N. Y.

Repulsion-Induction Motors

WAGNER ELECTRIC CORP., St. Louis, Mo., has recently developed an improved line of integral-horsepower type RG repulsion-induction motors. These motors have electrical characteristics that make them desirable for operating air compressors,

viscous liquid pumps, refrigerant compressors, conveyors, etc. The salient characteristics of the Wagner type RG repulsion-induction motor are: (1) High starting torque, (2) Low starting current, (3) Positive starting on low voltage, (4) High power-factor, (5) Excellent efficiency. The New Wagner repulsion-induction motors are available in sizes 1 to 3 hp., in vertical and horizontal types.

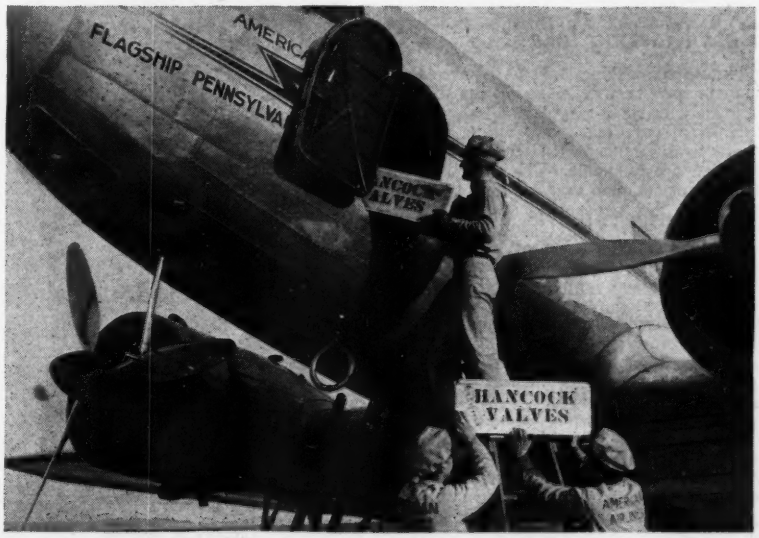
Close-Coupled Motor Pump

THIS PUMP known as Type H is designed for capacities up to 250 g.p.m. and heads up to 250 ft. at speeds of 1750 and

3460 r.p.m., the speed depending upon the required capacity and head. It is single suction, with a single stage enclosed im-

A Race Against Time

URGENTLY needed Hancock valves are shown being loaded into a plane to make a hurried delivery from Boston to Ohio so that a $3,000,000 public utility plant could be completed in time to avoid a penalty being paid by the construction company. Not included in the original order, the valves were suddenly needed at the last minute. Air express saved the day.



peller of standard bronze, the pump and splash proof motor being mounted to-unit, Adjustable bearing in the outboard end of the motor compensates for wear between the clearance spaces in the pump, hence no wearing rings are needed. These pumps can be installed in any position, horizontal or vertical, and their compactness makes them convenient for portable and semi-portable operations. Gradner-Denver Co., Quincy, Ill.

Pressure Oil Filter

TO MEET the need for larger capacities in one unit rather than a multiple of smaller ones in parallel, Wm. W. Nugent & Co., Inc., 410-412 N. Hermitage Ave., Chicago, Ill., has added three larger sizes of pressure oil filters to the five sizes formerly available. Construction and operation are similar to the well-known Size 4L except that eight, instead of four, textile filter bag elements are wound around a central spool. They will filter any liquid

that is not destructive to the materials. The new filters with an overall diameter of 18½ in., are known as Sizes 8R, 8S and 8L. The filtering surfaces are 4609, 9472 and 15496 sq. in.; the overall height 21, 31 and 43 in.; and the flanged pipe thread inlets and outlets are 1½, 2 and 2½ in. respectively.

Glass Marking Inks

INKS FOR marking on glass, porcelain and metal have been developed by the Westinghouse Electric & Mfg. Co. Glass marking inks in both black and white, which adhere to a surface when applied with a steel pen are available. The composition of these inks is such that it will not interfere with the vacuum conditions in a vacuum chamber where it may be used. If set by the application of a moderate temperature they cannot be removed completely by ordinary scraping. Both of these inks can be used on glass beakers, porcelain surfaces and thermometers, as well as for decorative effects.

A silver monogram ink, used primarily for the "W" monogram on Mazda lamps, has also been developed. This ink may be applied with a rubber stamp, but in order to fuse the metallic silver deposit into the glass, it must be dried by the application of heat. A black monogram ink, drying in two minutes, and which can be applied with a rubber stamp is also on the market.

F. M. Moves Offices

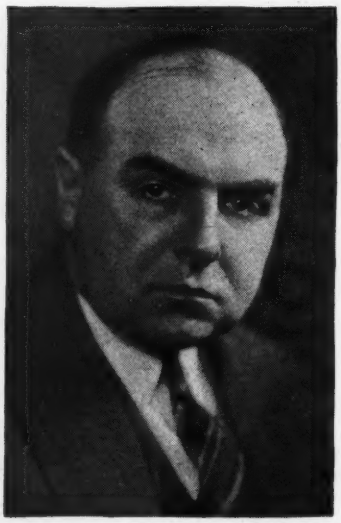
EARLY in January, Fairbanks, Morse & Co. moved its general offices to the modernized Fairbanks-Morse building at 600 S. Michigan Ave., Chicago. The company's new quarters have been completely remodeled and redecorated. The first five floors of the building are occupied by the executive, sales and departmental offices. In the display room on the first floor are shown some of the company's various products. Grouped about a ten-ton, eight-cylinder Diesel engine are electrical machinery, pumps, scales, railroad and farm equipment, household appliances, automatic coal burners and air conditioners.

Dexter P. Cooper

DEXTER P. COOPER, 57, well known hydraulic engineer died of heart disease at his home in Boston on Feb. 2 after a month's illness. With him passed any immediate prospect for the completion of the $36,000,000 Passamaquoddy tidal power project in the Bay of Fundy. This development originated with him many years ago and as originally conceived embraced both Canadian and American waters. Mr. Roosevelt was familiar with it long before he became president and it was one of the first P. W. A. projects undertaken, although modified from the original scheme so as to be an all American project. With his brother Hugh he was identified with many prominent hydraulic developments in this country and abroad, two of the most prominent being Muscle Shoals in the Tennessee Valley and Dnieperstroy in Russia.

Timothy A. Kenney

TIMOTHY A. KENNEY, president of the Consumers Power Co. and the Ohio Edison Co., and a vice-president and director of the Commonwealth & Southern Corp., died at his home in New York City January 19, after a long illness. He was 56 years old. Mr. Kenney entered the public utility field at the age of 16 with the Hudson River Power Transmission Co. He remained with that concern until 1912, when he went to Michigan as assistant manager of the Au Sable Electric Co., which had just been organized, to take over centralized operation of the generation and transmission facilities of several utilities then administered by the Consumers Power Co. as a holding concern. This brought him into association with the late J. B. Foote, manager, who soon assumed greater responsibilities and was succeeded by Mr. Kenney. In 1915 when Consumers Power Co. became an operating company, Kenney went to New York as assistant to President B. C. Cobb. He became president of Consumers and of Ohio Edison in 1932. Walter H. Sammis, vice president of Consumers Power Co., had been named vice president and director of Commonwealth & Southern Corp., succeeding Mr. Kenney.



Timothy A. Kenney

Milwaukee Honors Holzbog

JOHN H. HOLZBOG, Personnel Director of Chain Belt Co., Milwaukee, was the recipient of the Milwaukee Junior Chamber of Commerce Distinguished Service Award. Presentation was made at the January meeting of the Junior Chamber. Similar awards are made by Junior Chambers of Commerce in all important cities to men in the local communities, under 36 yr. of age, who during the year have made outstanding public service contributions.

The award given Mr. Holzbog was in recognition for his services in promoting industrial safety. Among the activities for which he received this award are the following: Chairman of the School for First Aid and Health. This school has five sessions a year and is attended by an average of 2500 people. Chairman of the Foundry Section and Sheet Metal Section of the Milwaukee Foremen's Safety

John H. Holzbog (right), receiving award from Dr. Glenn Frank

School which meets four times a year and is attended by about 6000. President of the Milwaukee Industrial Relations Association. Member of the Milwaukee Industrial Training Conference, whose purpose is to guide activities of the evening technical course at the Milwaukee Vocational School. Member of the National Metal Trades Association's apprenticeship committee. Financial Secretary for the Milwaukee Metal Trades Club. Addressed the National Safety Congress at Pittsburgh and Chicago and attended the National Safety Congress at Atlantic City. Member of the American Management Association. District Commander and Division Commander of the Milwaukee Community Fund for a period of years.

News from the Field

FRANK E. AURAND, JR., formerly associated with the Concrete Surfacing Machinery Co., Cincinnati, has bought from that company the Berg Cleaning Tool Division, including patents, and is expanding and carrying on the cleaning tool business under a corporate organization as Aurand Mfg. & Equipment Co. at 2643 Colerain Ave., Cincinnati, Ohio.

BLAW-KNOX Co., Pittsburgh, Pa., announces the appointment of N. B. Ornitz as president of the Power Piping Division of the Blaw-Knox Co., and of W. N. Quartz, as vice president in charge of operations. Mr. Ornitz, a director and a vice president of the Blaw-Knox Co., will also continue the management of the National Alloy Steel Division of the company.

E. KEELER COMPANY, Williamsport, Pa., announces the appointment of G. G. Van Tuyl as district representative for the company in the northern third of the state of Ohio. His address is 16701 Kinsman Road, Cleveland, O.

RALPH LEAVENWORTH, Fuller & Smith & Ross, Inc., Cleveland, will head the program committee for the 1938 Conference of the National Industrial Advertisers Association. The conference, sponsored by the Cleveland, Youngstown and Toledo Chapters of N. I. A. A., will meet September 21-23 at Statler Hotel in Cleveland.

Plans for the conference are progressing rapidly, according to Stanley Knisely, Republic Steel Corp., general conference chairman, whose committee on arrangements includes: Paul Teas, Paul Teas, Inc.; George Corey, Cleveland Twist Drill Co.; R. P. Dodds, Truscon Steel Co.; Richard Carr, Meldrum & Fewsmith Co. of Toledo.

E. B. Bossart, Bailey Meter Co., is chairman of the attendance committee. Louis J. Ott, Ohio Brass Co., George Corey, and K. W. Akers of Griswold Eshleman Co., are in charge of hotel arrangements.

E. L. Oldham, Cleveland Rock Drill Co., is attending to publicity; Harry H. Melville, Simmons-Boardman Publishing Co., is in charge of transportation; Robert E. Bandelow, The Caxton Co., is arranging for the display panels; H. W. Fortey, Warner & Swasey Co., is planning entertainment; J. L. Beltz, Thew Shovel Co., Lorain, Ohio, is looking after exhibits.

KOPPERS Co., Pittsburgh, Pa., has announced the election of Allen W. Morton as a vice president of the company. Mr. Morton will continue in charge of Koppers' American Hammered Piston Ring Division at Baltimore, where he has been general manager. Mr. Morton, a native of Richmond, Va., was graduated as a civil engineer from the University of Virginia in 1916. That year he was employed by the Bartlett Hayward Co., Baltimore, now a division of Koppers Co. Later he became associated with American Hammered.

WORTHINGTON PUMP & MACHINERY CORP. of Harrison, New Jersey, has announced the appointment of W. A. Meiter to the position of manager of its Buffalo, New York, sales office. Mr. Meiter has been a member of the Worthington organization since his graduation from Ohio State University in 1927, and has served the major portion of his time as a salesman in the corporation's Cleveland territory.

THE EXTENSION DIVISION of the University of Wisconsin, at Madison, announces that its elementary course in hydraulics—the basis of designs for the distribution of water, collection of sewage, and transportation of oils—was fully revised in January and now includes the latest applications of researches which make the computations fit the actual movement of fluids more accurately. The subject is taught by the department of civil and structural engineering by the correspondence-study method. This course teaches the fundamental theory of hydraulics, including the flow of fluids in pipes and open channels, the various devices used to measure flowing fluids, and the pressure of fluids in submerged surfaces. Included in it is a practical application of the viscosity of fluids and of the ratios used to make the formulas applicable to different conditions and fluids.

EDWARD F. CALLAHAN, general manager of apparatus sales of the International General Electric Co. has been elected a vice president of the company, it has been announced by Clark H. Minor, president. Mr. Callahan has been in the employ of General Electric and the International General Electric for thirty-three years.

Mr. Callahan was born in New Haven, Conn. Upon graduation from Yale University in 1905 with a Ph.B. in electrical engineering, he entered the test course of the General Electric Company at Schenectady. In 1911 he joined the G-E foreign department, and seven years later was made assistant to E. A. Baldwin, manager of the Department of Europe, International General Electric Company. In 1922 he became sales manager of the Department of Americas, and four years later was named general manager of apparatus sales for I.G.E. Since 1931 Mr. Callahan's headquarters have been in New York City.

ALLIS-CHALMERS MFG. Co.'s Publicity Department for power, electrical and industrial machinery was recently reorganized into two sections. George Callos is now assistant manager in charge of sales promotion embracing advertising, bulletins, exhibitions and house organs. A. K. Birch is assistant manager in charge of market analysis, sales organization service embracing price books, data and sales information, and the distribution of literature.

KOPPERS COMPANY has announced that it has acquired exclusive rights to the manufacture and sale of the line of valves and other waterworks and sewage equipment formerly produced by the Michigan Valve and Foundry Division of the Timken-Detroit Axle Co. Production of the line will not be interrupted. It will be produced under its present trade name by Koppers Company's Western Gas Division, Fort Wayne, Ind., and will be added to its "Western" line of valves, sluice gates and similar equipment, according to R. A. Wickes, general manager of the division.

FORESEEING an enlarging field of usefulness for electronic tubes, the Westinghouse Electric & Mfg. Co. has reorganized its manufacturing facilities at Bloomfield, New Jersey, to form the Special Products Division, under the management of H. J. Hoffman. The new Division embracing the design, manufacture and sale of electronic tubes will continue the manufacture of a complete line of radio transmitting tubes, including the 50-Kw type AW-200, the largest ultra-high frequency television tube made. It will also continue the manufacture of special ultraviolet devices, and complete lines of electronic tubes of industrial types, as well as X-Ray tubes and associated rectifiers.

With the movement of all industrial tube design from the East Pittsburgh Plant to the Bloomfield Plant, all phases of manufacturing and engineering of a complete line of electronic tubes and associated devices are concentrated at one plant.

PITTSBURGH & LAKE ERIE RAILROAD has received authorization from the Pennsylvania Public Utility Commission to replace a power house in Pittsburgh at a cost of $540,000. The plant will furnish heat, steam, electricity, water and compressed air to the railroad's facilities in the Pittsburgh terminal area. The present power house, inundated in the spring flood of 1936, is obsolete.

A. C. BLINN, Akron, Ohio, has been elected president of the Ohio Edison Co. He had been executive vice president and general manager.

DR. CARL THOMAS HUMPHREY, 54, dean of the Engineering School of Villanova College, Philadelphia, died at his home Feb. 6. He was a graduate of the Massachusetts Institute of Technology, and joined the teaching staff of Villanova in 1908.

ST. MAURIC POWER CORP., owned jointly by Shawinigan Water & Power Co., Ltd., and the Brown Corp., has applied to the Quebec Electricity Board for permission to proceed with construction of a 162,000-hp. hydroelectric plant at La Tuque, Que. Cost of project, including dam, power house and four generating units, is estimated at $12,500,000.

INFORMATIVE sessions for coal and stoker salesman are being held in Cincinnati, Ohio, Tuesday evenings, 7:30 to 9:30 p. m. in Room 1504, Carew Tower. Meetings of Feb. 15th and 22nd took up Stoker Design and Stoker Controls. On Mar. 1, the subject will be Selection and Application of Coals to Stokers by G. G. Ritchie, fuel engineer of C. & O. Ry., at Richmond, Va., and L. J. Whitlock of N. & W. Ry. Mar. 8 the subject will be Performance of Coals on Stokers by R. A. Sherman, Batelle Memorial Inst., Columbus, O. Mar. 15 meeting will be on Trouble Shooting in Stokered Plants by E. C. Webb, Iron Fireman Mfg. Co., Cleveland, Ohio, and this will be amplified on Mar. 22 by L. W. Garver, fuel engineer, Leckie Coal Co., Inc., Columbus, Ohio. Mar. 29 will be considered Comparison of Stokers, Gas and Oil Burners, by R. C. Cross, Batelle Memorial Inst., Columbus, Ohio. April 5 visits will be made to the fuels laboratory of Batelle Memorial Inst. in Columbus to witness stoker firing tests. The meetings are directed by T. A. Day, assistant secretary, Appalachian Coals, Inc., the fee for the entire course being $5.

JOS. C. LANG, formerly Works Manager, Automatic Business Machines, Inc., Pittsburgh, manufacturers of Robotyper, has resigned to become Chief Engineer with Brooke L. Jarrett & Co., industrial engineers of the same city. Mr. Lang brings to his new connection a long and varied experience in the engineering field peculiarly adapting him to the requirements of his new position. He was at one time associated with the National Cash Register Co., of Dayton, Ohio, and with the Dalton Division of Remington Rand, Inc., at Norwood, Ohio, as Designing En-

gineer. He was also one of the organizers of the Brulan Engineering Co., of Cincinnati, Ohio, consulting engineers. The Brooke L. Jarrett Co. specializes in the development of new products for established industry.

THE INDEX TO THE A.S.T.M. Standards and Tentative Standards for 1938 has just been published and can be obtained without cost from the headquarters of the American Society for Testing Materials, 260 So. Broad St., Philadelphia, Pa.

PROFESSOR WILLIAM N. BARNARD has been named director of the Sibley School of Mechanical Engineering in the College of Engineering by the Cornell University Board of Trustees. A graduate of Cornell in 1897, he has been, with the exception of two brief periods, a member of the faculty ever since. Since 1907 he has been professor of heat-power engineering. He has been head of the department for 18 yr. and during the past year and a half has been acting director of the Sibley School of Mechanical Engineering. His books on heat-power engineering, written in collaboration with C. F. Hirshfeld and F. O. Ellenwood, are standard textbooks in the field, and he has published numerous studies in technical journals.

A. S. T. M. Meetings

AMERICAN Society for Testing Materials announces that the society's 1938 regional meeting will be held March 9 at the Seneca Hotel, Rochester, N. Y. A. S. T. M. Committee Week, which will be held at the same hotel from March 7 to 11, inclusive.

From June 27 to July 1, the Forty-first Annual meeting of the Society will be held at Chalfonte-Haddon Hall, Atlantic City, N. J.

NATIONAL Bituminous Coal Commission issued on Jan. 28 a formal order approving Appalachian Coals, Inc., indefinitely as a marketing agency for southern coal producers, replacing the provisional approval issued last September. The company has functioned since April, 1933, to give service to its constituent companies and its customers on coals, coal burning equipment, market conditions and accounting, and traffic service.

A. L. LYNN has been appointed manager of the new division office of the Island Creek Coal Sales Co. at 402 Washington Bldg., Washington, D. C. Reiss Coal Sales Co., Sheboygan, Wis., is now affiliated with Appalachian Coals, Inc., as sub-agent for Anchor Coal Co., Island Creek Coal Co. and Cabin Creek division of Truax-Traer Coal Co. Also Milwaukee-Western Coal Sales, Inc., Milwaukee, Wis., will act as agent for Clover Splint, Island Creek and Cabin Creek Coals.

R. E. CHASE & Co., Tacoma Bldg., Tacoma, Wash., with branch offices in Seattle, Portland and Spokane, has been appointed representative of The Terry Steam Turbine Co.

ROBERT V. HAMILTON has been appointed Resident Sales Engineer in charge of the Birmingham district by The Foxboro Company, Foxboro, Mass. He will be under the direction of W. W. Barron of the Atlanta office.

TO MEET the demand for boiler equipment designed to withstand increasingly high temperatures and pressures, the Clees Valve & Engineering Co. is installing a new boiler in its testing laboratory at Newark, N. J., to provide steam at a pressure of 2500 lb. per sq. in. The boiler probably will go into service in March. This will supplement existing testing equipment capable of supplying steam at 1500 lb. per sq. in. and hydraulic facilities for tests up to 10,000 lb. per sq. in.

ANOTHER POWER HOUSE, a $5,000,000 steam-operated generating station with a capacity of 45,000 kw. is to be added to the Pacific Gas & Electric interconnected network of 49 hydro-electric plants and 10 steam plants. This new unit will be constructed at the refinery of the Shell Oil Co. on the outskirts of Martinez, California, and will be completed in 1939. It will duplicate in cost, equipment and output a steam-electric plant that the P. G. and E. has just begun to build at the Tidewater Associated Oil Co. refinery in the nearby town of Avon. Its features will include one turbo-generator and three 1,500 lb. boilers that will produce steam at 950 deg. F.

The Martinez power house will be erected under a cooperate agreement whereby the P. G. and E. will furnish the Shell company will electric energy and steam for its refinery and purchase from it fuel oil to operate the generating station. Shell's maximum electric demand will approximate 5,200-kw. and the balance of the power generated by the new power plant will be turned into the P. G. and E. system.

38 Millions for S. G. & E. System

STANDARD GAS & ELECTRIC Co's preliminary construction budget for 1938 will total $31,392,873 for operating companies in the system, not including The California Oregon Power Co. and Mountain States Power Company budgets which have not yet been approved by the respective boards of directors, according to Bernard W. Lynch, president of the company. Preliminary construction budgets for the individual operating companies are: Louisville Gas & Electric Co., $2,447,767; Market Street Railway Co., $578,607; Northern States Power Co. (Minnesota) and subsidiaries, $6,810,740; Northern States Power Co. (Wisconsin) and subsidiaries, $918,925; Oklahoma Gas and Electric Co., $2,861,257; Philadelphia Co., $12,543,598; San Diego Consolidated Gas & Electric Co., $1,572,016; Southern Colorado Power Co., $221,714; Wisconsin Public Service Corp., $3,310,699; Empresa De Servicios Publicos De Los Estados Mexicanos, S. A., $127,550. The amount of $12,543,598 indicated as the preliminary construction budget for Philadelphia Company includes expenditures contemplated by all of the subsidiary companies of Philadelphia Company. Included in this amount are estimated expenditures by Duquesne Light Co. of $8,276,690, and Equitable Gas Co. of $1,134,300.

Detroit Edison, 1938 Program

THE DETROIT EDISON CO. expects to spend approximately $18,000,000 for new construction during 1938, and nearly $8,000,000 of this will go for additions or betterments to the company's power plants.

Conners Creek Power Plant has been in the process of rebuilding for the past 6 yr. This was originally a 180,000-kw. plant with 14 boilers operating at 600 deg. F. and 225 lb. pressure. Three 20,000-kw. turbo-generators have been replaced with three 30,000-kw. units and two new 60,000-kw. units have been installed in an addition to the plant. Nine of the old boilers already have been replaced with new boilers operating at 850 deg. F. and 600 lb. pressure. Two more old boilers will be replaced with new ones in 1938 and the remaining three boilers will be removed.

During 1938 an old 45,000-kw. turbo-generator will be replaced with a new 60,000-kw. unit which will be ready for service about April 1939. After the changes now in progress are completed the only original equipment remaining in service will be one 45,000-kw. low pressure turbine which will be used as a peak load machine taking steam from the high pressure boilers through a pressure reducing station.

It is interesting to note that the capacity of this plant, when all these changes have been made, will have been raised from 180,000 to 315,000-kw.; the number of boilers reduced from 14 to 11; and the pounds of coal per kw-hr. generated will have been reduced from 1.42 before changes were started to an expected 0.91 in 1938.

An extension to the Delray Power House No. 3 to house three 75,000-kw. turbo-generators and six boilers was started in 1937 and will be completed in 1939. A new 75,000-kw. turbo-generator and three new boilers operating at 900 deg. F. and 815 lb. pressure will be installed in this addition in 1938. The first section of this plant, which has been in commision about ten years, included three 50,000-kw. turbo-generators and five boilers operating at 700 deg. F. and 400 lb. pressure.

A special 10,000-kw. turbine built by the British Thompson-Houston Co. has been used at the Delray Plant for several years to conduct experiments with high temperature steam. This experimental machine is now being rebuilt in England and will be sent back and put into service this year as a topping turbine, taking steam from the high pressure section of the plant and exhausting to the low pressure section.

About $1,700,000 will be spent for new Substations or additions and betterments to old ones at numerous locations in the 7600 sq. mi. served by the Company. Additional transformer capacity will be installed at several old substations and changes will be made at several stations to reduce the possibility of service interruptions.

About $4,250,000 will be spent on extensions and betterments to underground and overhead lines. It is expected that about 445 mi. of farm lines will be built to extend service to farmers in the proximity of present lines.

A new service building is under construction one block from the present general offices. The balance of the 1938 construction program will consist of betterments to underground steam lines that are used for the distribution of steam for heating downtown buildings in Detroit, the purchase of necessary items of equipment including automotive equipment, transformers and meters and many other small items that are classified as additions to plant investment.

Willard P. Chandler

WILLARD P. CHANDLER, JR., age 49, died January 24, at his home, 426 South Linden Avenue, Pittsburgh, Pa.

Mr. Chandler was chief engineer of the industrial division of the Blaw-Knox Division of the Blaw-Knox Co. and had been in the employ of the company since January, 1929. He was a graduate of the Engineering School, Cornell University, Class of 1910, and before coming with

Blaw-Knox, he had been identified with the Heat Economy Bureau, the Duquesne Steel Works and Clairton Steel Works of the Carnegie Steel Co.

He was a member of the American Iron and Steel Institute, the Association of Iron and Steel Engineers, the Engineers Society of Western Pennsylvania, the Izaak Walton League, the American Museum of Natural History, the Philatelic Society, and the Duquesne Lodge 731 F. & A. M.

Boiler and Turbine for University of Missouri

ON JANUARY 3 the University of Missouri ordered a 275 lb. pressure, 50,000 lb. per hr. steam generating unit from Babcock & Wilcox Co. and a 750-kw. back pressure turbine-generator from General Electric Co. for installation in the University's power plant at Columbia, Mo. The equipment was purchased on specifications issued by the University December 1, 1937, bids being opened December 28. Construction of seven new buildings in 1936 added over one-third to service loads, requiring additional generating equipment.

The boiler is a cross-drum unit fired with a chain grate stoker, having forced and induced draft, water walls, convection superheater and an air heater. The turbine-generator will take steam at 255 lb. and 600 deg. and exhaust to the heating system at from 30 to 70 lb. pressure, depending on heating requirements. The generator is equipped with a surface air cooler and a shaft exciter.

The two firms named above will make the installations complete, except for foundations, piping and wiring, which will be let on later contracts, after designs are completed from final construction drawings of the boiler and turbine. It is expected that foundation, piping and wiring designs will be ready late in March. Shipment of the boiler is expected in June and of the turbine in October. All work is to be completed and the new equipment in service by December 1, 1938.

Considerable economy improvement is expected from the new installation, due partly to better boiler efficiency, but even more to use of the turbine exhaust steam for heating. A further saving will be the elimination of power use by turbine auxiliaries during the time the new non-condensing unit is in operation instead of the present condensing machines.

Charles W. Stone

CHARLES WATERMAN STONE, 63 consulting engineer of the General Electric Co., died at his home in Schnectady February 3 after an illness which confined him to bed for nine weeks. Death was caused by heart trouble. He graduated from the University of Kansas in 1894, joined the General Electric organization in 1900 and was named manager of the Lighting department, now known as the Central Station department, in 1912. He continued in that position until 1928 when, at his own request, he was relieved of managerial responsibilities and became a consulting engineer of the company.

For the Engineer's Library

Any Catalogs that you wish will be gladly sent. Write Power Plant Engineering.

Water Treatment, Controls, Meters and Instruments

The Art of Proportioning—This new 24-p. booklet, describes the operation, construction and application of H-O-H Feeders operated by pressure difference between pitot tubes employing the Haering fluid piston principle. Copies of the booklet may be obtained from D. W. Haering & Co., Inc., 3408 Monroe St., Chicago, Ill.

W-B Periodic Process of Chlorination.—A publication in which this subject is discussed describes in detail the system and its operation for the prevention of algae growths in condensers and water lines. Specialties Engineering & Service Co., Hoboken, N. J.

Copes Flowmatic Regulator for feedwater control is described and illustrated in Bulletin No 409-A which has just been issued by the Northern Equipment Co., Erie, Pa.

Measurement of Pressure—A paper under this title, presented at the Oil World Exposition in Houston, Texas, and written by Norman Smith, Instrument Engineer of Crosby, deals with some of the problems confronted in measuring pressures in industrial plants and refineries. It has been reprinted and can be obtained from Crosby Steam Gage & Valve Co., 30 Church St., New York, N. Y.

Crosby Vapor Tension Gages are illustrated and described in a new 4-page folder just issued by the Crosby Steam Gage & Valve Co., 30 Church St., New York, N Y

Inferno Safety Unit is the subject of a bulletin which gives complete information in regard to the installation and operation of this feedwater regulating unit. The Inferno Co., Shreveport, La.

Power Transmission, Metallurgy

Speed Reducers—This booklet, Catalog No. 68, is attractively printed in three colors with interesting phantom and detail views showing operation of this combined speed-changer and speed-reducer. Four types are described, including new motorized and differential units, all with roller bearings, which allow any speed from zero up, and by special arrangement can vary the rotation past zero into reverse direction. A differential shaft permits the input power to be divided, part at constant speed through the differential, the remainder through the variable speed mechanism. Issued by Stephens-Adamson Mfg. Co., Aurora, Ill.

Variable Speed Transmission.—In Catalog No. 68 construction of the J.F.S. speed changer is illustrated and described, tables of dimensions of sizes from 1/6 to 12 hp. are given and numerous examples of applications to industrial drives are shown. Stephens-Adamson Mfg. Co., Aurora, Ill.

Sleeve Type Bearings—64-page catalog giving information to facilitate selection of bearing types and sizes. Alloys, tolerance and large range of sizes listed progressively. Special sections on oil grooving, flanged bearings and bushings and decimal equivalent chart. Johnson Bronze Co., New Castle, Pa.

High-Strength Alloys—36-page booklet entitled Hastelloy covers chemical and physical properties, available forms, methods of fabrication, machining and welding, and typical successful applications of Hastelloy alloys. Copies available from Haynes Stellite Co., Kokomo, Ind.

Industrial Friction Materials—Comprehensive data on the complete lines of industrial brake linings and blocks and clutch facings of cone and band types with a chart which simplifies the selection of the most suitable friction material for any specified service, covering such factors as rubbing speed, drum temperature, pressure. Supplementing this chart is a table which gives the coefficient of friction, size limits, thickness, tolerances and recommended service conditions for each of various types of J-M industrial brake linings and blocks and clutch facings. This bulletin, form FM-7A, is issued by Johns-Manville, 22 East 40th Street, New York City.

Pumps and Compressors

Centrifugal Pumps.—Goulds Bulletin No. 210 under this title gives complete details, data and tables on a new line of centrifugal pumps. There are 18 sizes with capacities from 5 to 1800 g.p.m. against heads up to 110 ft. for flat or V belt or direct motor drive. The most modern hydraulic design is embodied in casings, impellers, and stuffing boxes. Structural strength and amply proportioned parts are there without excess weight. Goulds Pumps, Inc., Seneca Falls, N. Y.

F-M Duplex Power Pumps—This 3-p. folder, Bulletin 6185, describes and illustrates this product in regard to design features. It may be had from Fairbanks, Morse & Co., Chicago, Ill.

Electric Driven Direct-Connected Compressors—The developments and refinements accomplished in over 30 yr. of manufacturing direct-connected synchronous-motor-driven compressors, are presented in a new 56-page catalog covering class "PRE" compressors. The catalog itself embodies several unique features, notable among them being a two-page chart devoted to the interrelation of the design of the compressor and its operation in service. More than 50 representative installations in all parts of the world occupy 20 pages of the catalog, No. 3426, copies of which may be obtained from Ingersoll-Rand. 11 Broadway, New York, N. Y.

Motor Pump—Close-coupled centrifugal motor pump of compact design for heads up to 250 ft. and in capacities up to 250 g.p.m. is described in Bulletin A-201 of the Gardner-Denver Co., Quincy, Ill.

Fordair Compressor—New designs and features are embodied in a new bulletin. The twelve pages involve a complete presentation of portable and stationary models with their specifications. New developments have been made through the use of the Ford V-8 block as a basic unit for this particular type of compressor construction and design. The bulletin may be had by requesting bulletin No. 3815-PG from Schramm, Inc., West Chester, Pa.

Steam Specialties

New Pipe Bending Equipment—A new circular covering this subject lists six different pipe bending sets, showing just what pipe sizes they may be applied to. These six sets cover practically every size pipe. American Pipe Bending Equipment Co., Inc., 37-39 Pearl Street, New York, N. Y.

Yarway Impulse Steam Trap is the subject of a 12-page bulletin T-1733, which gives complete information on the Yarway trap. Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa.

Homestead Lift-Plug Valves.—A pocket size 3-page folder under this title gives in condensed form the many features and applications of this product. Homestead Valve Mfg. Co., Coraopolis, Pa.

Tile Conduit—A revised, two color, 8 page Bulletin No. 35-67A on ADSCO-Bannon Tile Conduit and Corning Filler Insulation for underground steam or hot water lines, including illustrations of the products, details of construction and their applications, is available by addressing the American District Steam Co., North Tonawanda, N. Y.

Metal Hose—Packless, seamless flexible metal hose, its construction, uses and proper installation are described and illustrated in Bulletin 100 issued by Packless Metal Products Corp., Long Island City, N. Y.

Three Hundred Power Plant Specialties are illustrated in a new General Catalog No. 500. Equipment such as valves, gages, whistles, oil cups, are described, giving the features, applications, design and specifications of each item. J. C. Lonergan Co., 211-215 Race St., Philadelphia, Pa.

Diesel Engines, Electrical Equipment

Diesel Engines—In an attractive 3-color booklet are given curves for maximum and rated performance curves of Caterpillar Diesel engines for 7 different sizes. Also are discussed and illustrated the construction and details with tabulation of outside dimensions. Copies may be had from Caterpillar Tractor Co., Peoria, Ill. Ask for Form 4253.

A-C Generators for Diesel Engine Drive is the title of an illustrated booklet recently announced. Installations of generators connected to many styles of Diesels are pictured and the construction details of the electrical and mechanical parts are also shown. Descriptive material covers the main features and advantages of these generators. Copies may be secured from the Westinghouse Electric & Mfg. Co, East Pittsburgh, Pa.

Mechanically held Automatic Transfer Switches are treated in a new bulletin recently issued by the Automatic Switch Co. The 20 pages are illustrated with diagrams, charts, and other valuable technical information. A copy will be sent to any one upon request to the Automatic Switch Co., 154 Grand St., New York, N. Y.

Motor Generator Sets.—This new 20-page bulletin No. 1155-A illustrates modern construction of motor generator sets for various applications such as used in steel mills, mines, electrolytic and other services. It is divided into several sections such as the direct-current generators, synchronous motors, induction motor-generator flywheel sets, frequency changer sets, and sets for special applications, and control equipment. Allis-Chalmers Mfg. Co., Milwaukee, Wis.

U. S. Royal Cords and Cables—A new illustrated wire manual designed to provide electrical engineers, contractors, purchasing agents and others concerned with standard construction, with wire and cable data and specifications, has been announced by the Wire Division, United States Rubber Products, Inc., 1790 Broadway, New York, N. Y.

F-M Direct-Current Motors, designed to meet a wide range of requirements, are treated in Bulletin 2260. Construction details of direct-current motors in their various sizes are described and illustrated. Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago, Ill.

Metal-Enclosed Switchgear is the subject of a 40-p. Bulletin 66 which has just been issued by the Delta Star Electric Co., 2400 Block, Fulton St., Chicago, Ill.

Capacitors—Mica transmitting capacitors for radio installations in various types and capacities are described and illustrated in Bulletin 153A. Cornell-Dubilier Electric Corp., So. Plainfield, N. J.

Commercial Lighting Publications—Commercial lighting luminaries are described in three new publications entitled, The New Motif in Totally Indirect Illumination For Commercial Establishments, Silvurn Conditioned Lighting, and Magnalux Leads The Vanguard of Commercial Lighting Progress. These publications list applications for each unit, construction features and foot candle intensities for various mounting heights and spacing. Copies of these leaflets may be obtained from the Lighting Division of the Westinghouse Electric & Mfg. Co., Cleveland, Ohio.

Electric Tools—Features of a portable lectro-shear in 16-18 gage sizes for cutting sheet metal and a Utility power drill are given in two leaflets recently issued by the Black & Decker Mfg. Co., Towson, Md.

Electric Drive Selector and Hints on Maintenance is the title of a 12-page publication recently prepared. Arranged particularly for the non-technical man or for the plant maintenance man, the pamphlet describes and illustrates the requirements which must be met in selecting a motor. Copies may be secured from the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Heating Ventilation and Air Conditioning, Building Materials, Fans and Blowers

G-R Multiwhirl Cooler is the subject of a bulletin describing a liquid cooler with a wide range of applications for cooling lubricating oil from turbine and Diesel engines, jacket water from Diesel engines, quenching oil, transformer oil, and other liquid-cooling services. Copies of the bulletin will be sent on request for Form 710 from the Griscom-Russell Co., 285 Madison Avenue, New York, N. Y.

Refractories—Reprint of a paper on materials, manufacture and costs of refractories, by Paul M. Tyler and R. P. Heuer, is available from General Refractories Co., 1600 Real Estate Trust Bldg., Philadelphia, Pa.

Heating by Radiators—In a 16-p. booklet entitled Don't Be Hoodwinked, is presented a comparison of warm air and radiator heating for residential work, including a discussion of the real needs for heatnig, cooling, ventilation, cleaning and humidification, and their actual importance in the home. Copious illustrations and explanations emphasize the advantages of radiator heating. The booklet is interesting and informative. National Radiator Corp., Johnstown, Pa.

Heat Engineering—Reprint of a paper presented before A.S.M.E. by Martin Frisch on Trends in Steam Generator Design, showing details of arrangement and characteristics of modern high-capacity, high-pressure, high-superheat steam generating units. Copies available from Foster Wheeler Corp., 165 Broadway, New York, N. Y.

Duplex Strainers—Details of construction, sizes and capacities are given in an illustrated bulletin No. 100 of the Duoflo strainer, issued by Sheffler-Gross Co., Drexel Bldg., Philadelphia, Pa.

Centralized Combustion Control—Two publications, a 40-page brochure and an 8-page pamphlet afford a complete exposition of modern combustion control methods for the small and medium sized power plants as well as the larger plants. Up until a year ago Hays Control Instruments were offered through the Carrick Engineering Co., but early in 1937 Hays absorbed the Carrick Co. The Hays Corp., Michigan City, Ind.

Leak Repairs—Uses of Flextite for stopping leaks and waterproofing walls and floors is explained in a folder issued by Flexrock Co., 800 No. Delaware Ave., Philadelphia, Pa.

Vibration Prevention — Neoprene Notebook, planned to give engineers and manufacturers data on the use of Neoprene for joints and foundations to prevent vibration is issued by the Rubber Chemicals Division of E. I. du Pont de Nemours & Co., Wilmington, Delaware.

Tallmadge Zoned Controlled Heating Systems are illustrated and described in a new catalog which has just been issued by the company. Including several typical installations, the catalog gives a complete treatise of this subject. Webster Tallmadge & Co., New York, N. Y.

Tube Life—A new booklet describing how non ferrous admiralty and muntz tube life may be increased about three times. The increased tube life is being obtained by marine, power plants, industrial plants, and oil refineries using steam condensers and heat exchangers. Condenser Service & Engineering Co., Inc., 310 Twelfth Street, Hoboken, N. J.

Directory of Chemical Engineers—In addition to a complete list of members of the Association of Consulting Chemists and Chemical Engineers, Inc., is given details of the work in which they specialize, their training, experience and qualifications. Listings are alphabetical, geographical and by specialties. Published by the Association, 50 East 41st St., New York, N. Y.

Social Security—Second annual report of the Social Security Board is available from the Superintendent of Documents, Government Printing Office, Washington, D. C., at the price of 30 cents per copy.

New Engineering Books

HANDBOOK OF CHEMISTRY AND PHYSICS, 22nd Edition, 1937-1938; 2090 pages, 4¼ by 6⅞ in., complete cross index, bound in flexible fabricoid, price $6.00.

The Chemical Rubber Co., Cleveland, O. Charles D. Hodgman, Editor in Chief of this handbook, was assisted by 173 leading specialists in the preparation of this extremely complete and useful work, designed as a ready-reference book of chemical and physical data for students, teachers and technicians. With but very few pages devoted to instruction for the use of some tables and data, practically the entire book is filled with tables of nearly every scientific description. Antidotes for poisons, treatment for burns and scalds, and fire precautions are made conveniently available in the opening pages. Mathematical tables are unusually complete and occupy over 300 pages, they include those used in simple arithmetic on through all branches to calculus and the computing of probable errors. Nearly 600 pages are devoted to properties and physical constants including among others atomic weights; arrangement of electrons; isotropes; radioactive elements; constants of chemical compounds, oils, resins and minerals; and trade names of dyestuff intermediates. General chemical dyestuff intermediates. In the hands of an engineer or scientist who is familiar with fundamentals, this book of data is a convenient source of extremely useful information much of which is difficult to find in other places.

PROCEDURE HANDBOOK OF ARC WELDING DESIGN AND PRACTICE. Fifth edition; 1012 pages, 1243 illustrations, 6 by 9 in., leatherette binding. Lincoln Electric Co., Cleveland, Ohio. Price $1.50.

This is a concisely written and profusely illustrated complete arc welding reference guide, for use of designers, engineers, architects, production managers, welding supervisors and operators, with a wealth of data of interest to all who have to do with design, construction, costs and erection of welded machinery or structures.

The book is an encyclopedia of arc welding, which includes the results of years of study and experience, yet is revised each year to include all new essential data. It covers in detail and at length the subjects mentioned in the above outline, giving 140 examples of welded design of machines and parts, also the use of standard shapes in structural work in connection with welded construction.

THE LIFE HISTORY of George Westinghouse is now told in an 80-p. book published by the American Society of Mechanical Engineers. The coal-oil that lighted American homes had founded a fortune. Electricity, the new marvel, was for the wealthy who could afford it; and then only for those who lived within a few blocks of the direct-current generating stations. One man alone saw alternating current as the means of making incandescent light the servant of the masses. That man fought, single-handed, against the holders of patents based on direct current, and against ignorance; and although he was more than once threatened with legal restraint and financial ruin, he won.

In a literal sense, the book tells the story of electricity itself; for the author-editor, Charles F. Scott, professor emeritus of electrical engineering at Yale University, and most of his co-writers, were eye-witnesses not only of the struggle for the alternating current system, but of the coming of the modern high speed steam turbine, the air-brake, the improved transformer, the air-spring, the electric railway and a hundred other engineering feats associated with the name Westinghouse.

To Dr. Scott, who joined the Westinghouse organization in 1888, "the old man" was a genius whose greatest gift was the ability to see and utilize broad new principles, in a day when inventors were busy perfecting gadgets to run on old principles. A copy of this new book will be sent to you on request. Westinghouse Technical Press Service, East Pittsburgh, Pa.

THE ELECTRICAL YEAR BOOK, 1938. 312 pages, cloth, 4 by 6 in., illustrated. Emmatt and Co., Ltd., Manchester, England. Price 1/6 net (about 40c).

In addition to a general revision of this edition of this well-known little book, particuliar attention has been given to certain aspects of power generation and distribution. New information has been provided on phase sequence, symmetrical components, leakage protection, distance protection and the protection of A.C. motors. As always, it is a useful, practical little book, well worth the low price at which it is sold.

SIGNIFICANCE OF TESTS OF COAL. Published by the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa. Size, 6 by 9 in., paper bound, 132 pp. Price $1.00.

This is a symposium of six papers presented at the 14th annual meeting of the Society in New York City last June. It gives in convenient form detailed discussions of the meaning of the results of tests of coal. Papers cover interpretation of laboratory coal tests, proximate analysis and calorific value, significance of sulphur in coal, significance of ash softening temperature and ash composition in the utilization of coal, laboratory results relating to caking, plastic, gas and coke making properties, significance of friability and size stability, pulverizer performance as affected by grindability and other factors.

AIR CONDITIONING. By Richard E. Holmes. Published by McGraw-Hill Book Co., Inc., New York, N. Y. Size 6 by 9 in., 296 pages; cloth bound. Price $3.

Mr. Holmes, who is designing engineer with Westinghouse Electric and Manufacturing Co., states as his purpose to produce a book for readers with good technical knowledge but with no knowledge of air conditioning, and to give them thorough grounding on the important phases of the subject. It is based on instruction given in classes for technical workers over a period of 2 yr.

The author has started with discussion of the Nature of the Atmosphere, pressures, temperatures, mixture of water with air and the measurement and effects of relative humidity on human comfort. This brings in properties of air, of water vapor and of mixtures of the two. Construction and use of the "comfort charts" is explained, the requirements for ventilation and the effect of wall or "panel" heating on temperature and humidity necessary for comfort.

Following this is a description of air conditioning systems and what constitutes real air conditioning. Then is discussed what constitutes winter load on a system, in the need for heating and humidifying, also summer load in the way of cooling and dehumidifying, including transfer of heat by conduction, radiation, air infiltration.

Systems of heating, of humidifying and of air cleaning are each given a chapter, followed by the application of various equipment for winter conditioning. As refrigeration is necessary for summer cooling, the principles and practice of refrigeration are treated at considerable length, followed by an explanation of the equipment used and its application to cooling and dehumidifying air for summer air conditioning.

A final chapter is devoted to temperature and humidity controls for maintaining desired conditions. Equipment is well illustrated, numerous tables of data give the tools needed for making calculations, and examples are worked out to show how to use them.

Treatment of the subject is well planned, explanations and discussions are clear, the material is presented interestingly yet so well condensed that the information may be digested with a minmum of time and effort.

TRANSFORMER PRINCIPLES AND PRACTICE. By J. B. Gibbs. First edition, 210 pp., cloth, 6 by 9 in. illustrated. McGraw-Hill Book Co., Inc., New York, N. Y., 1937. Price $2.50.

Here is a very good book on transformers for those who are interested in the subject from a practical standpoint and who want a nonmathematical discussion. While a number of books on transformers have been available for a number of years they are for the most part theoretical in nature and of interest largely to designers and students. This book is of a more practical nature, of interest to the man operating transformers. It is a simple, nonmathematical description of single-phase and three-phase transformers, auto-transformers and instrument transformers, covering a wide variety of related problems such as transformer insulation, oil, coils and cores, cooling, testing, ratio adjustment and phase transformation; as well as care and operation of transformers.

NATIONAL ELECTRICAL CODE HANDBOOK. By Arthur L. Abbott. Fourth Edition. 562 pages, size 5 by 7½ in. Bound in semi flexible fabricoid, illustrated. McGraw-Hill Book Co., Inc., New York, N. Y., 1937. Price $3.00.

The purpose of this book is to enable the reader to grasp readily the general plan, scope and intent of the National Electrical Code requirements. It is not the Code itself. Copies of the Code are available to everyone at a nominal price so, as the author points out in the preface, it seemed unnecessary to include a word-for-word reprint of the Code rules. All the requirements of the Code are presented, but some rules have been reworded where the purpose of the book could be better served by so doing. The book will be found helpful as a reference book by all users of the Code, and also as a textbook for individuals and classes taking up a systematic study of the Code.

Power Plant Construction News

Calif., San Francisco—Coca-Cola Co., 310 North Avenue, N. W., Atlanta, Ga., plans installation of electric power equipment in new beverage-manufacturing and mechanical-bottling plant near Third Street and Carroll Avenue, San Francisco, where site is being purchased. A power house will be built. Entire project will cost over $850,000. Pacific Coast offices of company are at 963 East Fourth Street, Los Angeles, Calif.

Fla., Miami—Fleischer Studios, Inc., 1600 Broadway, New York, N. Y., plan installation of electric power equipment in new motion picture plant in vicinity of Thirtieth Avenue and N. W. Seventeenth Street, Miami, where site has been selected. It will consist of three large units. Entire project will cost about $250,000. C. Sheldon Tucker, Seybold Building, Miami, is architect.

Ill., Joliet—Joliet Home Laundry Co., 137 East Jefferson Street, plans installation of power equipment in connection with rebuilding of mechanical laundry plant, recently destroyed by fire. Loss estimated over $70,000, including equipment.

Ill., O'Fallon—City Council is arranging early call for bids on revised plans for new municipal electric power plant, including installation of engine-generator units, boilers and auxiliary equipment. Also for a municipal electric distributing system. Bids received on previous call were recently rejected. Cost about $175,000. W. A. Fuller & Co., 2916 Shenandoah Avenue, St. Louis, Mo., are consulting engineers.

Ind., Tipton—Stokely Brothers Co., 2002 South East Street, Indianapolis, Ind., plan installation of electric power equipment in connection with rebuilding of food products canning and packing plant at Tipton, recently destroyed by fire. Loss estimated over $400,000. W. A. Miskiman is vice-president in charge of production.

Iowa, Durant—Common Council is considering a new municipal electric power plant. Cost estimated close to $100,000. Proposed to arrange bond issue in that amount for project.

Kan., Alma—Common Council has plans maturing for new municipal electric power plant. Proposed to use Diesel engine-generator units and auxiliaries. Cost estimated about $50,000. A bond election will be held soon. Paulette & Wilson, 1006 Kansas Avenue, Topeka, Kan., and Farmers' Union Building, Salina, Kan., are consulting engineers.

Ky., Louisville — Louisville Water Co., 435 South Third Street, has rejected bids recently received for two pumping units and accessories for waterworks station, with rated capacity of about 30,000,000 gals. per day, and proposes to ask new bids soon. L. S. Vance is chief engineer.

La., Hammond—Natalbany Lumber Co., Hammond, plans installation of power equipment in connection with rebuilding of planing mill and wooden box plant near city limits, recently destroyed by fire with loss estimated at $50,000. A boiler house is under consideration.

Mich., Bessemer — City Council will begin work soon on new municipal electric power plant, held up by court injunction and now dismissed. Installation will include two 320-kw. Diesel engine-generator units and complete accessory equipment. Cost estimated at $187,000. Financing has been arranged through Federal aid.

Mich., Newberry—State Department of Institutions, Lansing, Mich., has plans under way for new steam power house at institution at Newberry, with installation to include three watertube boilers, two steam turbine units, feedwater heater, coal-handling and other equipment. Cost estimated at $250,000. Derrick Hubert, 1065 Sheridan Road, Menominee, Mich., is architect; E. R. Little Co., Ford Building, Detroit, Mich., is consulting engineer.

Mich., White Pigeon — Eddy Paper Corporation, Three Rivers, Mich., has plans maturing for new power plant at branch mill at White Pigeon, estimated to cost about $300,000, with equipment.

Minn., Madison—Common Council is considering installation of a new Diesel engine-generator unit and auxiliary equipment in municipal electric power plant. Other improvements will be made at plant. A bond issue of about $132,000 will be arranged for entire project.

Mo., St. Louis—Griesedieck Brothers Brewing Co., 1920 Shenandoah Street, plans installation of electric power equipment in new two-story addition to brewery, 160x185 ft., to be used in part for expansion in mechanical-bottling division. Entire project will cost close to $150,000. Jannsen & Jannsen, Chemical Building, are architects.

Neb., Grand Island — City Council, Floyd S. White, city clerk, plans extensions and improvements in municipal electric power plant, including installation of new equipment. Cost about $68,000. Financing is being arranged through Federal aid. E. T. Seeley is city engineer.

N. Y., Yonkers — Refined Syrups, Inc., 120 Wall Street, New York, N. Y., plans installation of electric power equipment in new plant at Yonkers, where company has acquired part of former sugar refinery of Spreckels Sugar Corporation, and will improve and equip for plant. Entire project will cost close to $700,000.

Ohio, Bellefontaine — City Council has plans maturing for extensions and improvements in municipal light and water station, including installation of a 1000-hp. boiler unit, stoker and auxiliary equipment. F. M. Baxley is chief engineer.

Ohio, Cleveland—Eaton Mfg. Co., 739 East 140th Street, plans extensions and improvements in steam power house at automobile equipment-manufacturing works. Work will be carried out in conjunction with modernization and improvements in main plant. Additional equipment will be installed. Entire project will cost about $75,000. George S. Rider Co., Terminal Tower Building, Cleveland, is consulting engineer.

Ohio, Yellow Springs — Board of Trustees, Antioch College, plans extensions and improvements in power house at institution, including installation of a new 300-kw. Diesel engine unit and auxillary equipment. Cost estimated about $50,000.

Okla., Enid—Eason Oil Co., plans installation of power equipment, pumping machinery, tanks and other equipment in proposed rebuilding of portion of gasoline refining plant, recently destroyed by fire. Loss estimated at close to $400,000.

Pa., Josephtown — St. Joseph Lead Co., 250 Park Avenue, New York, N. Y., plans extensions and improvements in power house at plant at Josephtown, in connection with an expansion and betterment program at works, estimated to cost about $150,000. Additional equipment will be installed.

S. C., Greenwood—Greenwood County Finance Board, Greenwood, will receive bids until March 14 for power dam, power house and spillway for hydroelectric generating station at Buzzard Roost. In near future bids will be asked for hydraulic turbine units, as well as other power plant equipment. Entire project will cost in excess of $1,200,000, with power lines. E. L. Brooks is chairman.

Tenn., Chattanooga—Electric Power Board, Municipal Building, N. J. Simmons, secretary, will receive bids until March 14 for transformers and auxiliary equipment for power substations Nos. 1, 2 and 6 (Sub-Project Contract No. 3A).

Tenn., Pulaski — General Shoe Corporation, 511 Gallatin Street, Nashville, Tenn., plans installation of electric power equipment in new branch plant at Pulaski, where building will be erected by municipality and occupied under long-term lease. Entire project will cost over $100,000. Hart, Freeland & Roberts, Third National Bank Building, Nashville, are architects.

Texas, Houston — Armour & Company, Union Stock Yards, Chicago, Ill., plans installation of electric power equipment in new meat-packing plant on Lockwood Street, Houston, where large tract of land has been acquired. It will comprise several units. A power house will be built. Entire project will cost close to $1,000,000. Company engineering division, first noted address, is in charge.

Texas, Houston—Nowery J. Smith Supply Co., 3610 McKinney Street, plans installation of electric power equipment in new oil well equipment and drilling machinery manufacturing plant in Eureka Junction district, where site has been secured. Work will begin at once. Entire project will cost over $100,000.

Wash., Spokane—Spokane Breweries, Inc., 901 West Broadway, plan installation of power equipment in connection with expansion and improvements in plant. Proposed to begin work soon. Entire project will cost about $100,000.

W. Va., Bandy — Youghiogheny & Ohio Coal Co., Commonwealth Building, Pittsburgh, Pa., plans installation of power equipment in new coal-mining plant and tipple at coal properties in vicinity of West Junction, near Bandy, where company has tract of about 2300 acres of land. Entire project will cost close to $300,000.

Wis., Milwaukee—Hummel & Downing Co., 208 East Wisconsin Avenue, plan installation of electric power equipment in new additions to paper-box manufacturing plant, including improvements in present structures. Entire project is reported to cost over $350,000.